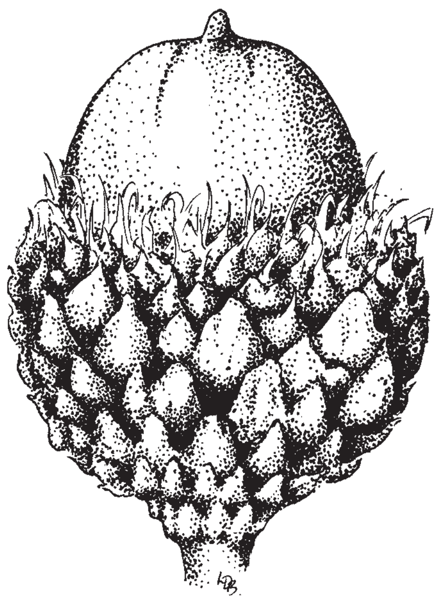
Discovering God's Creation



A Guidebook to Hands-on Science

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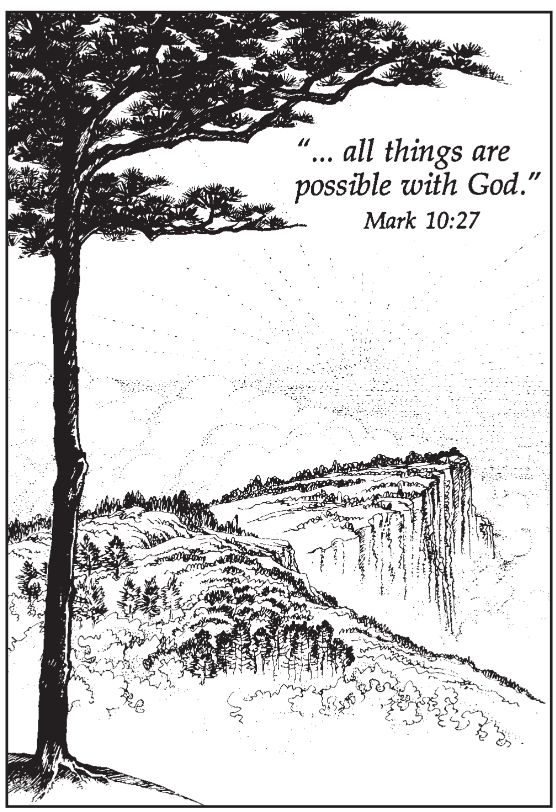
by grade level

Please note: Grade level designations are approximate. Although grade levels are indicated for most lessons, whether a lesson is suitable for a particular group of children depends on the children—their background and experiences—more than on a particular age. The suitability of a particular lesson also depends on the way in which the lesson is taught.

High School

How a Scientist Works


"... all things are possible with God."
Mark 10:27

Preface

In the days when the high, wild prairie grasses still covered the Midwestern plains, lightning regularly caused fires that swept the land. The fires were frequent enough so that they were not fuel-loaded and, hence, burned relatively coolly. Nevertheless, they consumed everything in their path. That is, until they came to the burr oaks that lined the river valleys. Here the high kindling temperature of the oaks stopped the fires and thereby protected all the other trees in the river valleys.

The large, old oaks standing on the campus of Martin Luther College are distant reminders of that protection. Thus the oak was chosen to be a fitting symbol for this project. The oaks separate and guard the valley, creating an environment in which growth can occur. All educators stand like oaks at the interface between students and the world's knowledge.

Such a view of educators is not new. Some years ago Drs. Robert Yager and James Wandersee toyed with the idea that science educators were analogous to the vital membrane around a biological cell. Following Yager's lead, Wandersee nicely listed these unique functions of science educators: (1) structuring scientific knowledge for learning, (2) translating the language of science, (3) designing teaching materials and activities, (4) presenting science content in a variety of ways, (5) studying how students learn, and (6) helping the students to integrate thought and action. In Christian schools all these educational functions become subject to the overriding principle that humans can never read the revelation of God in nature fully nor draw conclusions correctly and with certainty (Becker 68). When we do science, we are limited by our humanity. Sure knowledge is found in Scripture alone, but Scripture is no science book. As Galileo said, Scripture tells us how to go to heaven, but not how the heavens go. Understanding the formal and material causes in nature is the continuing work of the sciences, but the efficient and final causes are found only in the Word. As my colleague Marty Sponholz writes later in this volume, the two are separate and must not be confounded.

We need to show science to our children from this explicit scriptural viewpoint. First, science is to be highly valued as a human activity. Science is mankind's effort to understand the Creation. God blesses us through it. This kind of knowledge is vital to our well-being and in carrying out our stewardship of earth's resources.

On the other hand, science is limited to understanding natural causes and building natural explanations. Furthermore, history shows us that science changes. Clearly, the laws that science discovers are not the same as the laws of nature. Science sees through a glass darkly, with a narrow view influenced by assumptions and theories. Discoveries can be kaleidoscopic: beautiful and useful but still superficial and tentative.

So it follows that we cannot use selected science to support Scripture. Science is changing stuff. What happens to faith if it depends on reason? The church has no business favoring particular scientific theories. Even if such ideas seem to support Scripture, they could be discredited. Science and Scripture must be kept separate.

Nevertheless, we will want to point out that the wonder, complexity, and beauty of creation tells us that there is a God. As St. Paul states in the first chapter of Romans, we have no excuse to deny God's existence. But while nature declares that there is a Maker, science does not. Science limits itself to natural causes. William Kyle stated in *The Journal of Research in Science Teaching* some years ago that, if God is real, we must realize that science could never discover Him.

Science and theology have different sources of knowledge, different assumptions, different methods, and different standards of proof. In one the Spirit works; in the other we are on our own. No wonder that St. Paul, who was highly educated, concluded that in spiritual matters, he "resolved to know nothing ... except Jesus Christ and him crucified....so that your faith might not rest on men's wisdom, but on God's power" (1Co 2: 2-4).

We must remind ourselves that many Creationists are of a different spirit. Lutherans and Calvinists have had this difference before over the nature of the elements in communion. We believe in Creation by faith and by Scripture. Do we not confess in Luther's Third Article that by our own "reason and strength" we would never come to God and faith? Do we not sing "All my knowledge, sense and sight lie in deepest darkness shrouded"? Let us apply this in science: My science cannot not make me believe in God. My science cannot bring me to God. The Spirit does not work through test tubes and microscopes. Scientific creationism is well-meaning, but misguided and dangerous.

In 1980 I told the Bible-Science Institute that the Bible was not a science book or some type of guide to superior general knowledge for living on earth, and I referred to Jacob's scientific effort to influence the color of the offspring by the placing of sticks in front of the breeding cattle. God made it work for Jacob but does not comment on the validity of Jacob's science. God could have had Moses add a disclaimer on the science, but he does not. Such a disclaimer might cause more problems and questions than good. Such a disclaimer would distract from the purpose of Scripture. God simply makes no comment on the science.

After the meeting the *Bible-Science Newsletter* published a retort. The author claimed that Jacob knew something that we do not: The sticks must have been radioactive or chemically mutagenic and were able cause mutations in the cattle. That kind of strange and forced scientific support does nothing for my faith. The story of Jacob and my present day knowledge of genetics makes me appreciate all the more how God can do anything he wants. The whole story, the theme of Jacob's life journey, tells us everything about any clever human efforts to help God.

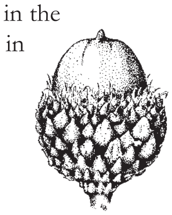
The lessons in this book assume that the child has faith that was created by the Spirit through the Word. Our lessons will then see the universe differently. Our teaching will exclaim, "Look at how God did this!" "Is not this wonderful?" Yet we will have to be careful not to draw the picture too sharply. For example, the DNA molecule does not declare the wonder of God as much as the whole general complexity of inheritance does. DNA theory is very likely to be too simple an explanation and may someday join phlogiston chemistry, cold-blooded dinosaurs, and caloric heat theories on the scrap heap of human thinking. It is in nature that we recognize the complexities and wonders. Our changing science shows us that our understandings are tentative and superficial. We must be humble.

It is also good to remind our children that the nature we observe is a nature that is suffering. What we observe may not be what God intended at Creation. Why does the white pelican have two offspring at a time? The second egg is laid two days after the first. The larger sibling pushes the smaller out of the nest, the parents do not recognize the little one once it is out of the nest, and it often dies. Does God not care? Of course, God cares. He would not have created the pelicans if he did not delight in them. With Job we must admit that we do not understand all these things...but clearly the whole creation is in pain, waiting for redemption.

Let the burr oak remind you of the important place that good teaching has in our schools. The Lutheran view is unique; the approach in education requires care.

In the summer of 1995, using a grant from the Aid Association for Lutherans, we invited twenty-six teachers to participate in the Science Curriculum Institute on the Martin Luther College campus. At the Institute the teachers contributed their favorite activities and ideas for the publication of this book. Monies, given to the Board for Parish Education (CPS) by an anonymous WELS donor, were used to cover the publication costs of *Discovering God's Creation.* This book represents many areas of science but does not claim to be comprehensive. However, it will guide you philosophically and give you examples of activities that are dear to other teachers in our church body. We hope that you can supplement your program with many of them. In planning your school's curriculum it would be valuable to agree on where these activities will be used. We hope *Discovering God's Creation* encourages you and will be a blessing in your ministry.

Discovering God's Creation would never have been finished except for the contributions of the teachers attending the Science Curriculum Institute, the editorial assistance of Roger Klockziem and John Paulsen, the organization and drive of John Micheel, the excellent layout work and thoughtful reactions of John Isch, the encouragement of Marty Sponholz, and the careful proofreading of Gerald Jacobson, Arlen Koestler, Jeanette Boehlke, and John Micheel. Dr. Arthur Schulz, Vice-president for Studies in the Educational Ministry at Martin Luther College, encouraged the editors to provide appropriate Christian applications in the science lessons. The fine drawing skills of Lucas Boehm who drew the acorn of the burr oak on the cover also deserve recognition.



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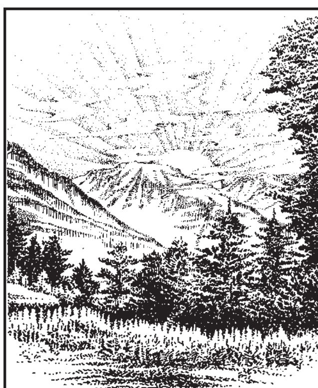
Paul Boehlke



By faith we understand that the universe was formed at God's command, so that what is seen was not made out of what was visible.
Hebrews 11:3

Different!

Nature and science are different. This difference is simply that, since the Fall of mankind, nature and science can not be the same until we take up residence in our new heaven and new earth. Teaching that this difference cannot be overcome must dominate the science classroom of the Christian teacher.

Nature can be defined as all of the physical and biological universe which our almighty God created and continually maintains. This natural world is a broken creation. Yet, in spite of its groaning and longing for the day of restoration, nature still reveals the awesome brilliance of its Creator (Ro 8:22; Ps 19:1).

Science, on the other hand, is an ever changing body of knowledge based on scientists' attempts to explain the natural world. Some of these scientists might be Christian but many are not. More typically a scientist today will be one who demands even the expulsion of the word "creature" because today's science has no place for a "Creator" (Bellig 1987, 155-158).

The Christian teacher knows and must pass on to the next generation that the order seen in nature was put there by our Lord. The very command of God to man and woman, "…fill the earth and subdue it" (Ge 1:28), is the command to study and learn of nature. However, since the Fall "…every inclination of his heart is evil from childhood" (Ge 8:21). Even when using our great gift of reason, as sinners we will twist views and logic to avoid seeing the order placed in nature as His signature (Ro 1:19-23).

For example, the awesome order seen by Francis Crick (1988) in the DNA molecule, for which he received a Nobel Prize in 1962, was seen by him as the very mechanism of evolution. He did not see the blueprints, purpose and guidance of the Creator but rather a self-steering chemical system by which all things climbed a ladder of nature by natural selection. To Francis Crick, "scientific knowledge made religious beliefs untenable" and he could not see God's hand behind the double helix.

The fundamental task for science educators, who teach all things in the light of God's Word, will be to teach this separation between science and nature. On this side of Heaven, science, at its best, can be only an inadequate human-drawn picture of the natural world.

The problem of keeping science separate from nature and God's Word is not only related to works of the ungodly evolutionists. Christian teachers must see and teach this separation whenever they would venture forth with their own reason to explain nature. This includes the most well-meaning creationist who tries to overcome errors of some scientists by using more science. Creationism, while well-meant, is still based on human reason and loaded with speculative artistry. The Christian teacher must recognize that such reasoning is always a potential stumbling block to Christian faith. Any supportive human theories and laws, even if they seem to fit Scripture, can fail and may then cause problems for Christians.

Creation, the great flood, the many miracles of Jesus, and the resurrection of the dead are the great bench-marks of faith. When teaching these events, Christian teachers would do well to keep the reasons from science mute. The Holy Word tells enough, speaking most clearly and exactly with certain truth. And over the centuries church leaders have correctly followed and advocated the pathway of trusting the word as sufficient. The wisest man, Solomon, said of mankind's efforts to understand:

> I, the Teacher, was King over Israel in Jerusalem. I devoted myself to study and to explore by wisdom all that is done under heaven. What a heavy burden God has laid on men! I have seen all the things that are done under the sun; all of them are meaningless, a chasing after the wind.
>
> … This only have I found: God made mankind upright, but men have gone in search of many schemes. When I applied my mind to know wisdom and to observe man's labor on earth—his eyes not seeing sleep day or night—then I saw all that God has done. No one can comprehend what goes on under the sun. Despite all his efforts to search it out, man cannot discover its meaning. Even if a wise man claims he knows, he cannot really comprehend it.
>
> … Remember your Creator in the days of your youth…. (Ecc 1:12-14; 7:29; 8:16-17; 12:1)

St. Augustine commented on combining Scripture with man's wisdom:

> Certain philosophers, it is true, did get a glimpse of the truth amid the fog of their own fallacies and did try to build it up to solid conviction and persuasiveness by means of carefully worked-out argumentation—such truths, for example, as God's creation of the world, his providential governance of it, the excellence of virtue, of patriotism, of loyalty in friendship, of good works and all other things pertaining to morality. They saw these things even when they did not know what final end, or how, they were to be referred. But in the City of God these truths are found in the words of the Prophets—God's words, even though spoken by men. And they were not driven into her people's heads amid the tumult of twisting and turning argumentation, but simply delivered to them. And those who heard them trembled, for they knew that if they despised them they were despising not the wisdom of man, but the word of God. (412)

Some have always hoped that a true Christian science could be developed. But Martin Luther knew that reason could not stand equally with Scripture:

> No reason is so firm that it cannot again be overthrown by reason. There is no counsel, no matter how wise, no thing, no edifice, no matter how magnificent or strong, which cannot again be destroyed by human counsel, wisdom, and strength. And this can be seen in all things. Only the Word of God remains to all eternity (Luther as quoted by Becker, 1982, 38).

C. F. W. Walther and Charles Darwin were contemporaries. Note how the gifted Lutheran theologian resisted turning to a defense of reason and instead called Christians back to faith alone, scripture alone, and grace alone:

> The charge is indeed valid that in our efforts to lead the present unbelieving generation back to faith we make no attempt to demonstrate to the world the harmony of faith and science. But we see no reproach in this charge; rather we glory in it, and we will not, by the grace of God, permit anyone to rob us of this glorying. For we are very certain that it is not possible to help the present apostate world with the lie that the divinely revealed truth is in perfect accord with the wisdom of this world; only the preaching of the divine foolishness, of the old unaltered Gospel, can help the world. Paul as well as the history of the church of all ages and of every Christian testified that the "foolish Gospel" is the power of God unto salvation to all that believe, to the Jew first and also the Greek (Ro 1:16). A person who has been won for Christianity by showing him that Christianity can pass the sharpest probe of science is not yet won; his faith is no faith. (As quoted in Pieper, 1951, 164)

Siegbert Becker's finest writing was on the proper place of reason in Lutheran theology (1957):

> It is this that man must learn that true knowledge can be found only in God's revelation, and God's revelation is to be found only in Scripture. Because of man's total depravity and blindness, he can never read the revelation of God in nature fully nor draw conclusions correctly and with certainty. God must come to our aid, but because of man's weakness and sinfulness, the majesty of God must hide behind the masks in order to reveal itself. Men should take care lest in sinful pride and presumption they are offended by the lowliness of the masks and by the simplicity of Scripture. It is the crib in which we find the Lord Christ. And only as we find Him there, and God in Him, can we know all creation correctly. (89)

Some believe that at least the facts of science should be true and trustworthy. However, in a series of educational monographs, the Wisconsin Synod (Sitz, 1955) presented a consistent Scriptural picture of the role of man's reason in comprehending nature. Wisdom separated from God's true Word is no wisdom at all. Even the facts are clouded:

> Now it may be contended that purely geographic facts can be taught and learned from a neutral point of view, without specific Christian or anti-Christian bias (the same may be said for scientific facts). Facts are facts, it might be said, without regard to the glasses through which they are viewed. However, that, too, is an erroneous notion. Facts, knowledge, ideas, if they are true, are creatures of God as truly as are the fowls of the air and the plants and herbs of the field. If these "bare facts" are separated in any fashion from their origin, divine creation, that very circumstance causes a distortion which makes of them something false and misleading. For origin is always an absolutely essential factor in any essence; and if that is clouded or denied, the entire picture is out of focus and thus becomes false and misleading. Only that can be true altogether that conforms in every part to the truth, the Word of God .

Paul G. Eickmann (1962), science professor at Northwestern College, saw reason as a servant and reminded us of the Third Article of the Apostles' Creed:

> Where God has spoken, reason must bow in submission, every thought must be subjected to the obedience of Christ. In this wise is our approach to all things directed and our attitude conditioned. This attitude is the result of faith that we have in Christ Jesus as our Savior, faith that has been created by the Holy Spirit through the Sacrament of Baptism and the preaching of the Gospel of salvation. It is not a result of an ability to reason, it is in fact entirely unreasonable. We make confession of that in the Third Article of our creed. "I believe that I cannot by my own reason or strength believe in Jesus Christ, my Lord, or come to Him, but the Holy Ghost has called me by the Gospel, enlightened me with his gifts, sanctified and kept me in the true faith." All the forces and influences that are involved in the creation of our faith are foreign to our nature. They negate our natural volitions and militate against the natural inclinations which reason would require us to follow. Reason has been dethroned and faith in Christ enthroned as the guiding principle in our lives. This is the attitude with which we approach all things in life and therefore science also.

While science is the study of nature, it is imperative to teach that the basic understanding of the difference between science and nature rests in history. The history of science is by far the most overlooked and neglected instrument in the science educator's classroom. When it is neglected by the Christian educator, the science student suffers a triple loss. Without history Christian students may fail to see the human artistry in science, they may fail to learn of the important roles played by Christians in the development of science, and they may not receive the full spectrum of understanding which Christian educators have to offer.

> Science professes to know more than it knows. In reality it can find only material and formal, or instrumental, causes, but in its ignorance it imagines that it has found efficient and final causes. (Becker, 1982, 66)

Without history such philosophical insights into the limits of science are totally missed. Christian education alone fulfills the need to find the efficient and final causes by identifying God as Creator and Preserver.

Only through the history of science will the student see the limitations of science. Only through the history of science will the student see the major changes of the laws of science. Only through history will the student see the human artistry in science that scientists impress upon the phenomena of the natural world. Only through history will the student see that the great contribution of experimental science was invented by Christians. Only through history, where the rise and fall of the many different theories of evolution can be learned, will the student be able to take measure critically of the current theories of evolution.

Interestingly, today most of the national curriculum studies also call for the inculcation of history into all sciences. To bring science alive, to capture the moment of scientific discovery and demonstration; students throughout our nation are being encouraged to read the original words of great scientists: to see how they themselves presented their evidence, arguments, and conclusions to their contemporaries (Cheney, 1989). This is to be part of their general studies in college. Furthermore, Project 2061: Science for all Americans strongly recommended the inclusion of the history of science in grades K-12 to show how the scientific enterprise operates and changes.

The Bradley Commission on History in Schools (1988) also emphasized the need to show how things change. This commission valued the preparation of the attitude of the history student; let us include the science student. Science students must learn to live with uncertainty, realizing that not all earthly problems have solutions. In so far as science is entirely a human endeavor, this reality of dealing with uncertainty in science is exactly what the Christian educator must get across to the science students of the twenty-first century. Nature is real and true but our science is limited and always changing.

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MS

Teaching Science In the Lutheran School

The goals of science instruction in Lutheran schools include the following general objectives:

To encourage educators to value science as an integral part of education
To use strategies that teach the following:

- ❖ All students of science should come to see the wisdom and skill of the Creator.
- ❖ Stewardship of the Creation needs to be taught. Good stewardship is only possible through understanding as much as possible about the Creation works. This compels us to learn science.
- ❖ Science should not be selected to prove or support Scripture. Science changes. Faith alone, Scripture alone, Grace alone;" these are all at risk if we seek to build a rational structure for our faith.
- ❖ Science should be presented from an explicit scriptural viewpoint:
  - seeing science as a creative human activity,
  - seeing science historically as a changing body of knowledge,
  - recognizing that the laws of science are not the laws of nature,
  - recognizing that all creation is suffering because of sin, and
  - recognizing that scientific ideas and the Scriptures should not be confounded.
- ❖ Science should be seen as filled with both blessings and limitations; we might trust our lives to science and technology, but not our souls.
- ❖ All science should be seen as tentative.
- ❖ Science education should promote active science lessons hands-on activities and thought provoking demonstrations that facilitate and sustain student engagement.
- ❖ Learning in science should be meaningful, and vocabulary should be useful: rejecting rote learning of abstractions from texts and the abuse of vocabulary tests.
- ❖ Educators need to use different kinds of questions in science: including the "why."
- ❖ Educators need to promote guided discovery and be willing to learn with the students.
- ❖ Collaborative learning may be used in a variety of science activities especially problem solving
- ❖ The classroom should reflect an excitement that is based on doing activities; science should not be confined to and driven by the textbook.

PRB

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What is it like to be a scientist?
What is it like to be a science educator?

An experienced teacher reflects on her efforts to produce science activities in the summer teacher's institute that created this book and catches the spirit of the scientist and the science educator. Her thoughts come from hours spent on perfecting an activity dealing with the rainbow. The process becomes as important as the product in hands-on science.

Often we think of a scientist as someone in a white coat in a large laboratory with test tubes or skeletons or balances or acids, at least someone with a vast knowledge of how to use these things. It is true that this may be part of being a scientist, but is this the essence of what one does?

After having spent some hours trying to perfect the duplication or replication of a very simple fact of nature, I believe that anyone and everyone can be a scientist, at least to some extent. I believe it is our duty as Christian teachers to begin to get that attitude instilled in our students so they feel that they can be scientists, too. Maybe a simple, childlike view will illustrate my point.

What is it like to be a scientist? You get an idea! It's just a simple idea! I only need two things. Do it, and it's done! But...it doesn't work!

Move this. Turn that. Get a smaller one. Get a larger one. Try a different angle. Maybe the distance is wrong. Does the light affect it? Now I have a mess! This doesn't work! But it's supposed to be so simple! Only two things are needed! It has to work!

Maybe if I get others to help me. They might be able to see what I can't see. They may have an idea I don't have. I'll talk to a friend!

We still don't have it right! Let's call another friend. We know one who has lots more scientific experience than we have.

But he can't get it either! Look at the time! Hours are gone and all I have is a mess and two frustrated friends. Should I give up? I don't have to do this experiment. I can switch to something else. But it would be so neat if it worked! I'll sleep on it.

With a fresh day the juices flow again. I'll keep on trying. I talk to some others who have had more experience. They suggest a new wrinkle or two. They watch. They assist. They encourage. They are sure it can be done. They suggest talking to someone who has more experience than they.

I go to that person who becomes as interested and excited as everyone else. Does that ever help! Even though we work together for an hour, we still aren't satisfied. It's lunchtime, and a scientist has to eat. At lunch I get another idea to try. We will move everything to another spot and just change one thing at a time. We need to control those variables. It's working! We're excited! We've done something that no one, as far as we know, has tried before, and we have gotten it to work!

Maybe you have picked out some of the qualities a scientist needs. You need an idea. You need patience, courage to try, willingness to change, the ability to accept someone else's ideas, encouragement from friends and colleagues, time to be able to think and rearrange, and finally the blessing of our gracious Lord who gives us these gifts.

Sounds pretty much like a Christian classroom, doesn't it? Does it sound like your classroom? If you let ideas flow, if your students cooperate, if you allow time, and if you encourage; it could be your classroom. But what if an idea fails? Wasn't it a waste of time? Certainly not! Many things will still be learned: organizing materials, managing time, critical thinking, cooperative learning, and the joy in following curiosity. Not the least is the value of following role models who are encouraging, empathetic, and sympathetic if need be. Things will be learned which will help in the next project; and finally you and your students will be hooked on science, hooked on learning about the things God has given us.

I have to quit now. I have another idea to try.

BK

General Guidelines for Science Safety

Most of what goes on in science teaching is not dangerous. Nevertheless, some risks do exist for both the students and the teacher. Currently science class injuries represent about 10% of all school injuries (using data from Gerlovisch). However, risks can be minimized if the teacher is prepared and aware. This section presents general guidelines for avoiding mishaps while teaching science.

1. First, the teacher should have a clear set of instructions on how to do the particular activity. Obviously, the author of these instructions needs to be qualified. Does the source seem to be conscious of safety? Major textbook publishers are generally quite careful about possible hazards in the activities they recommend. The printed directions are the teacher's best defense against accidents and legal action. These instructions for the activity should specifically point out any possible hazards.
2. The teacher must rehearse the activity before it is used in the classroom. This step cannot be overemphasized. When a teacher rehearses the activity before the lesson, he or she can assess both the safety and the likely success of an activity. Careful preparation in science education requires time.
3. Any activity that is hands-on or that is presented as a demonstration which involves heat, steam, pressure, animals, unfamiliar chemicals, high momentum, electricity, or sharp tools should give the teacher special reason to anticipate accidents or hazards. Rules, warnings, and guidelines that apply to a particular activity should always be reviewed with students before the activity begins. Failure to instruct and supervise properly is one of the most frequent causes of school accidents. Teachers are expected to foresee the reasonable consequences of their actions and inactions. Some general thoughts include the following:

   a) **Heat** Although heat is a danger, a teacher can hardly avoid the use of fire in science, even in the lower grades. Children need to learn about the use and misuse of fire (Thompson).
   Know this rule: Approach a hot object with the back of your hand; do not touch the object. If you feel heat, do not attempt to pick the object up. It is too hot to handle.

   b) **Alcohol burners** These burners are especially hazardous. They can easily be tipped over, quickly spreading fire. Safe storage is also a problem. Do not use alcohol burners; use candles or hot plates instead.

   c) **Steam** Water heated to where it is changing into a gas is invisible and contains not only the heat that has raised its temperature to 100º C but it also has the heat of vaporization. You can receive very bad burns from water in the gaseous state.

   d) **Pressure** You should never heat a closed system. If you heat a closed container, you will likely cause an explosion. Water vapor or chemicals may also escape and burn students.
   Vacuum tubes such as a television tube may implode, and glass can hit the student. Sometimes only a slight bump may cause the implosion. Because of the danger of shock and implosion, old TVs have no place in school.

   e) **Animals** Animals can provide valuable experiences in the classroom. However, wild animals should not be kept in the classroom. If a student is bitten by a classroom animal, the animal must be kept for observation to determine whether the animal has rabies. The principal and the parents must be notified. Also parents should be told to consult with their doctor regarding the bite and also ask about the need for a tetanus booster shot (Thompson).
   In general, students should be taught to wash after handling any animals or animal food. Warn children not to put their hands into their mouths after handling animals. The hands are the chief means by which germs are spread.
   Washing hands after handling iguanas, turtles, snakes, or other reptiles is especially important. The Centers for Disease Control and Prevention (CDC) estimate that 90% of reptiles carry some strain of intestinal bacteria. Salmonella bacteria is common on reptiles. Keep reptiles away from food preparation areas. Do not wash cages, food dishes, and aquariums in sinks where human food dish ware is washed. Anyone with a weakened immune system, including pregnant women, should avoid handling reptiles. Some states do not allow animals in classrooms.

   f) **Chemicals** Read the warnings on the Material Safety Data Sheets (MSDS) that come with any chemicals ordered from a science supply company. Keep all MSDS available where the chemicals are being used. Order only amounts that are needed; keep as little on hand as possible. Be sure that all chemicals are clearly labeled. Teach students never to inhale, touch, taste, or eat chemicals from science classes. Clean up spills immediately even if they are only water. Read all labels three times: when the bottle is picked up, as it is being used, and when it is being returned to storage. Never return unused chemicals to a stock bottle. Teachers should keep chemicals locked up to prevent unauthorized use.
   The National Safety Council states that when a person handles chemicals that are new, that individual should seek advice from other knowledgeable staff, read the literature (MSDS and directions), advance with caution, experiment with small quantities, protect with shielding, and use safety glasses and/or face shields. Never proceed without a knowledge base.
   Good directions for a lab activity will warn the teacher about any specific chemical dangers. Safety data sheets should also be available. Do not perform activities without directions in writing; as the level of instruction increases, so do the hazards. Secondary teachers will profit from checking specific warnings in the Merck Index if safety data sheets are not available for older chemicals that might still be in their store rooms.

Large amounts of mercury were given away in the 1960s as surplus material and may still be found in some schools. Mercury is extremely toxic and should never be handled. It must be kept in a closed container. Also, thermometers used by the students should contain alcohol, not mercury, in case they break.

Acid is always added slowly to water when making dilute solutions, not the other way around. If water is added to acid, large amounts of heat can be released and dangerous splattering of hot acid may occur. Sulfuric acid is very hazardous in this respect. The fumes from concentrated hydrochloric acid require that the dilution be done under a fume hood.

Do not store open containers of flammable solvents in ordinary refrigerators. The refrigerator can explode if the fumes reach unshielded sparks.

g) **Projectiles or high momentum situations** Guns (air or otherwise) or arrows should not be used in school. If an object travels at high speed, it should be blunt and its mass should be kept low. One science writer recently recommended a centrifugal force demonstration in which a set of keys was spun around into orbit on a string. Consider what would happen if a student were hit by the keys. Schools should not allow rockets with flammable propellants in school or on the grounds.

h) **Sharp tools** If there is something that must be cut by a sharp tool, the teacher should consider doing it for the students.

i) **Blood** Drawing human blood for typing involves the risk of serious infection. Students and teachers must be aware that hepatitis (liver infection) and HIV can be spread by accidentally sharing lancets or by body-fluid-to-body-fluid contact. Such an activity is inappropriate for the student before high school and even then must be done with extreme care.

j) **Electricity** Electrical wall current (115-120 volts) should not be used by students for experimentation. Television picture tubes can hold a charge and thus present a shock hazard even after they are unplugged.

k) **Storage** Schools should have a locked science equipment storage area to prevent unauthorized student access to equipment and chemicals.

l) **Special effects** Science teachers should never attempt to provide special effects (smoke, explosions) for plays or other school events. Smoke and fumes are not safe.

m) **Glass tubing** Glass tubing is involved in many accidents. As the tubing is being pushed into a rubber stopper, the tube may break and stab the user. Substitute plastic aquarium tubing for glass tubing if no heat is involved. The teacher should handle the glass tubing if it must be used. Unless the teacher has had experience working with tubing in a chemistry class, he or she should find a fellow staff member who has. Follow these guidelines: (1) the end must be smooth (fire polished), (2) wet the end of the tubing to reduce friction, (3) wrap both hands with a cloth in case of breakage, and (4) work close to the stopper.

The highest injury in science classes involves glassware and glass tubing according a study in 1977-79 of 847 student science injuries in Iowa public schools (Gerlovich). Schools should discard broken or cracked glassware. Teachers should use pyrex or another heat-resistant glassware when heating is involved. Glass tubing should be inserted into rubber stoppers according to the rules. In the elementary grades an experienced teacher should do it for the students.

Factors in Science Accidents, Grades 1-12 (Gerlovich)	
Glass	21%
Chemicals	18%
Animals	13%
Another person involved	10%
Laboratory utensil	6%
Metal item	4%
Thermometer	4%

n) **Heating test tubes** Teachers or students should never point a test tube which is being heated with the open end toward a person. The contents may suddenly fire from the tube. This is known as “bumping” and is caused by local boiling of water in the tube. When water changes state from liquid to gas, its volume increases about a thousand-fold. The tube should never be more than half full. As it is being heated, the teacher or student should hold the test tube with a holder and tilted at a 45-degree angle away from all people.

o) **Goggles** Wear protective eye goggles when working with hot molten materials, grinders, caustic or explosive materials, hot liquids or solids, radiation or when using heat treatment, welding, or when repairing or servicing of any vehicles. Even heating hot water in a test tube requires goggles. Goggles must be disinfected if shared by students. Some states, including Wisconsin, require the use of goggles in the situations described above.

4. If the activity is hands-on, students should be given the directions before they receive any equipment. Important steps and warnings can be written on the overhead projector or the blackboard. Students tend to listen poorly when they have new equipment in front of them. Make every effort to have them understand all the directions and warnings before they start.
5. When the activity is hands-on, students should be regularly reminded to work within the framework of the directions they have received. There should be no unauthorized experimenting! Students should know this policy and be reminded of it.
6. If the teacher says “freeze” or some similar command, the students should understand that they should stop what they are doing

and wait for an announcement or further direction. Students should move slowly in a science laboratory.

7. Schools should have the policy of reporting all injuries to the principal and the student's parents so that the situation can be evaluated. The principal will not want to be surprised by a call from the parents. A principal who knows what has happened is in a better position to support the classroom teacher.
8. Students should not be allowed to work alone in a science laboratory or on a science project. The science teacher should remain in the room while any activity is in progress.
9. A teacher of science is responsible for the student's instruction, supervision, and safety. Failure to provide for any of these can make the teacher and the school liable (Gatti, quoted by Willems).

If a rule is broken, a teacher should take step to assure that the infraction will not occur a second time. If a teacher does not take any action, grounds for liability may occur on the basis that the rule did not actually exist (Gatti, quoted by Willems). Horseplay or blatant disregard for safety rules on the teacher's part is inexcusable (Willems). Neither should one hear about science teachers who drink their coffee out of beakers, refuse to wear safety goggles, or are flippant about safety in any way.

Injury is generally foreseeable in many situations: (1) where large crowds of students are gathered without supervision; (2) in specialized activities in vocational education, physical education, and science classes; (3) in cases where the teacher is absent from the room (Gatti, quoted by Willems).

In cases where the student is directed by the teacher to do something and the student is injured, the courts have uniformly held that the child is not negligent no matter what his age (Gatti, quoted by Willems).

"Negligence exists where the activity or conduct on the part of the teacher creates an unreasonable chance of danger. When the teacher ignores the danger or does not see the danger when he should, he may be held negligent if someone is injured as a result" (Gatti, quoted by Willems, 5). On the other hand, a teacher has usually not been found liable if it can be shown that the activity was performed in a reasonable manner. A common defense is to show that the student was negligent in following directions. The standards of judgment involve the practices that generally prevail in all science classrooms. The warnings that come with directions and materials, and the practices that are generally used by most science teachers would be cited.

A teacher who avoids teaching science with activities because of safety concerns represents a negative approach to his or her teaching responsibilities. "The science teacher who remains in the classroom while experiments are in progress, who properly instructs pupils in the use of materials, and who maintains a continuous safety program, should have little to fear of liability" (Rice, et al. 45). Students should sense an air of concern for their safety.

While the information and recommendations contained in this publication have been compiled from sources believed to be reliable, we can make no guaranty as to, and assume no responsibility for, the correctness, sufficiency, or completeness of this information. Additional safety measures may be required under particular circumstances.

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The activities in this book worked for the teachers who wrote them. We have tried to present them as clearly as we could. It is finally the responsibility of each teacher to rehearse these activities and to judge their appropriateness and safety for his or her students.

Design, layout, and graphics by John Isch

1. Investigating a Puzzle

Equipment Needed

An opaque paper bag containing a metal spoon, optional materials might include an identical opaque paper bag which is empty, other dull objects which can be placed into paper bags, measurement devices such as a ruler, a scale; a number of different bags might be prepared and numbered for individual investigation

Purpose

To provide students with introductory experiences using the basic skills and processes of science: observing, inferring, measuring, classifying, predicting, comparing, recording data, basing inferences and conclusions on data. At the advanced level to indicate that scientists can and do err in their conclusions. This activity would work well early in the term.

Safety—Special Considerations

Objects in the bags should not be sharp. The lesson is relatively easy to manage; arrange the classroom to allow everyone to have a clear view. The teacher should be able to carry the package to every student.

Grade Level—Time Needed

Can be adapted to a variety of grade levels, K-12; can be adapted to a variety of science subjects by varying the contents of the packages. Time varies with age group and item being investigated.

Background

Since this is an introductory lesson, it is recommended that you open the bag(s) and show the contents at the end of the lesson. Point out that scientists cannot do this when they investigate nature. Many students need to see what is in the bag to build confidence in their own ability to reach a valid conclusion. They also need to understand the limitations of scientific investigation. You may wish to begin the session with some history of a famous scientist's initial question or problem and briefly describe how the person became interested in it. The Salem Press reference series on Nobel laureates edited by Frank N. Magill gives comprehensive information on each laureate's life and career written at the high school level.

Procedure

Hold up the bag containing the object for all to see. *We're going to investigate a puzzle package. Please do not call out, it interferes with thinking. Think about what we could do that would help us learn about the contents of this package without opening it. Raise your hand when you have an idea that you would like to try.* (Wait for 3-5 seconds before recognizing a student). The most common responses might be to feel it or to hold it up to the light. Follow up on a student response. *Would you like to feel it?* If the student agrees, take it to him/her. If not, ask for a volunteer. Explain what an observation is. As Officer Joe Friday of the classic TV series always said, "Just the facts, Ma'am." Don't allow guesses or inferences, ask for and accept only observations. Continue to guide students to gather more information about the contents. The bag could be weighed or the size of the object measured through the paper bag using the ruler. After enough evidence has been gathered to make logical conclusions, allow the students to make inferences and think about how confident they are with their conclusions. Explain that an acceptable inference is one that makes sense according to all the observations and data gathered. It is possible to have more than one acceptable inference. *Do you think that scientists ever investigate something they cannot see? Scientists cannot see many things that they investigate such as the wind, electricity, the inside of an atom. They must rely on the best possible information they can gather. If the information seems to fit together and agrees with other things that are believed, the more confident they are about their conclusions.* Point out that there are details that were missed. Perhaps the student failed to indicate the material of which the spoon was made (metal, plastic).

Older students will benefit from considering if we can ever really consider only the facts, only the observations. Usually we approach nature with something already in mind. *Our facts tend to be bent to fit our preexisting theories. Can we be truly objective? Can we be fooled? Do we tend to select particular facts and miss others?*

At the upper levels the teacher could place a spoon and a small piece of paper into the bag. Chances are that the students will not detect the piece of paper. Open the bag and discuss the situation. Our senses are limited and more importantly observers tend to find things that they expect to find. Expectations and assumptions greatly influence our observations and conclusions.

The experience can be set up as a laboratory exercise with many such puzzle bags available. Bags could be numbered. Students could report their findings to the group. "I think bag number 5 contains …."

Related Children's Literature

Take Another Look by Tana Hoban; *Look, Look, Look* also by Tana Hoban; *Walk With Your Eyes* by Marcia Brown; and *The Look Again...and Again, and Again, and Again Book* by Beau Gardner.

Assignment

Follow-up discussion questions—*How do doctors, dentists, veterinarians make observations? Do you want them to make observations without opening up the patient?* For upper grade/secondary students chose a scientist, research his beginning observations. *Can you find a specific starting point? Did the scientist come to a different conclusion at a later time? Did other scientists come to different conclusions?*

The teacher may also assign /suggest specific things to be observed by students individually or in teams. These results can be recorded on a data sheet (see sample).

Family Involvement

Send information home with children about the procedure. Have parents and children make a game of trying the same procedure at home using household items. Objects chosen should be dull.

Christian Application

God, in His infinite wisdom, has not given us full understanding of His creation. However, he has given us the ability to observe, record, name, measure ,describe, estimate, predict, classify. Sin limits all our abilities, but we can also form hypotheses, make inferences, design experiments, form models, and propose theories. The understandings that we gain can be great blessings. Still, we must realize that our science can be wrong and that our conclusions are likely to change with time. We need to remain humble as we attempt to gain knowledge. The book of Job contains a list of many things in nature that we do not understand and calls us to humility in both spiritual and physical matters (Job 38:1-41: 34).

Extension

Investigate other puzzle packages, and record the observations and data on a table (See sample). Record at least one inference by sketching a model of what is believed to be the contents of the package based on observations.

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How a Scientist Works— Lab Investigation

Name:______________________________ **Date:**__________________________

Package	Observations	Measurements	Assumptions	Inferences	Sketch

2. The "Oobleck" Experience: Observing and Recording Properties

Equipment Needed

One bowl of Oobleck for each team [4 boxes of cornstarch to 1600 ml (6 3/4 cups) water, about 15 drops of green food coloring makes enough for 24-36 students or 6 teams of 4-6 students], each work station covered with old newspapers, one large sheet of paper with a marker or crayon for data recording per team

Purpose

To investigate the properties of Oobleck, to improve observation and encourage critical thinking skills through investigation, to bring out feelings of curiosity, wonder, and discovery which is the heart of scientific investigation

Safety—Special Considerations

Use inexpensive, plastic bowls, allow about 45 minutes to prepare the Oobleck, set up the work stations for lab investigation, keep an additional box of cornstarch on the side to thicken the mixture in case it becomes too soupy. Recipe: add 15 drops of green food coloring to 1 liter ($4^1/_4$ cups) water, add 4 boxes of cornstarch and another 600 ml ($2^1/_2$ cups) of water, swirl and tip the bowl to level the contents, then place the bowl aside. About 15 minutes before the activity mix the Oobleck by hand to assure even consistency; keep 'lifting' the Oobleck from the bottom to the top by slipping your fingers under it until an even consistency is reached. The Oobleck should flow when you tip the bowl, but feel like a solid when you hit it or rub your finger across the surface. Although the substance is not toxic, do not let them taste it. **Do not pour oobleck into the sink because it is likely to clog the drain.** Dry Oobleck can be dumped into the wastebasket.

Grade Level—Time Needed

Wide range of age levels; younger students: open-ended, creative; older students: more involved in discussions, able to make better measurements. Time: Teacher preparation = 45 minutes, lab investigation = 45 minutes

Background

Many people see but are not careful observers. Ostlund (1992) gives advice on how to assess hands-on student performance. Encourage students to look for the characteristics that make something what it is...its unique properties. Encourage quantitative observations that include measurements. Observations can include some standard unit of size, weight, and temperature if applicable. This activity can be extended by observing and describing other objects or substances. Since this substance is so engaging, often the only way to gain control of the entire class is to remove the bowls of Oobleck. Oobleck's properties are due to the structure of the starch molecules which are very long chains. Each link in the chain is a sugar molecule. Imagine what would happen if you had a pile of chains to move around.

Procedure

Divide the class into teams of 4-6 students, spread newspapers on each area where students will work. Pour about 350 ml (1 1/2 cups) of Oobleck into each team's bowl (N.B. Oobleck can be vacuumed or swept up when it is dry.)

Tell students to imagine that they are scientists gathering to investigate the properties of an ocean sample from outer space. Inform students, *"Oobleck" is safe to handle. Your job is to investigate the properties of Oobleck.* (See Background information.)

Tell each team to investigate Oobleck for a few minutes with just their senses. *You can touch it, feel it, look at it, push on it, but do not taste it. Keep the Oobleck on the newspaper. Record the properties of Oobleck that you observe. How is this material like other materials? How is it different? Is it solid? Is it liquid? List as many properties as you can. Number each property.* Younger students should be encouraged to use large, clear letters. You may wish to have the teams designate their recorders. Next suggest that students test their ideas by experimenting. *How fast will Oobleck flow down an inclined plane (vis-*

cosity)? Time it. Compare Oobleck to water. How much does a certain volume of Oobleck weigh (density)? Again compare the Oobleck to water. Set the bowls of Oobleck aside until the next day so your students can see what the material looks like when it dries. Question: *If Oobleck is ocean "water," what would this mean for organisms that live in it? What would they be like?*

Family Involvement

Send the Oobleck recipe home with students.

Assignment

Ask each team to put a star on their list next to the property of Oobleck they think is the most important in explaining under what circumstances Oobleck acts as a solid or liquid.

Post the list of properties on the board or wall. Plan a "scientific convention" (See Activity 3)on Oobleck for the next day. Draw a picture of a creature that could live in Oobleck.

Christian Application

God has given us his entire creation to explore. Using the faculties he has given us, we marvel at the wonder of it.

Extension

For younger children (and older children) read *Bartholomew and the Oobleck* by Dr. Seuss. Read stories of discoveries by scientists (Haines). Tell the stories of pseudoscientists and how they use observations to argue for a flat earth, for flying saucers, or other odd conclusions (Gardner). Sprung (1985) has many activities using the scientific method in early childhood. Vancleave (1993) has more gooey activities.

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"Curiosity... is the heart of scientific investigation."

3. Scientific Convention: Follow-up to "Oobleck" or "Puzzle"

Equipment Needed

Posted lists of properties on wall or chalkboard, "Oobleck" or "Investigating a Puzzle" equipment on hand in case it is needed.

Purpose

To follow up on Activities 1 or 2. Scientists communicate their findings and hold conventions. The goal is to find answers and state them completely and clearly, and perhaps come up with a law or discovery. The give and take of ideas at such meetings is important in agreeing on conclusions.

Safety—Special Considerations

Follow rules of order. One property should be described at a time. Agree, disagree, discuss, or reword so everyone agrees.

Grade Level—Time Needed

Grade levels: varies, depends on items used in "Puzzle" lesson. Older students may explain why "Oobleck" behaves as it does. Time: varies, depends on age group, 20-45+ minutes.

Background

Physicist and philosopher Thomas Kuhn has pointed out that scientists tend to come to agreement when they are operating with the same assumptions and are also agreed on other laws and theories of science; that is, when they share the same paradigm. History shows that paradigms change with time. The truth of one age is replaced by a new way of looking at nature.

Procedure

Explain to your students that professional scientists often meet to discuss various topics. They listen to each other's experimental results and observations and discuss them. The goal of the convention is to find agreement, and state it as clearly and completely as possible.

Disagreements are jumping-off places for fruitful discussions. Challenge students to find ways of changing the wording so everyone can agree on the property. (Add a phrase, define terms.) Sometimes further investigations/experiments are the only way to resolve the disagreement.

Assignment

Write a summary of the "convention." Research an historic convention and report to the class on the controversy and the result. Make a poster of the "Laws of Oobleck."

Family Involvement

Many times families hold "conventions" when they discuss activities, vacations, problems, rules, discipline, etc. Recall your most recent or significant family "convention."

Christian Application

Christians communicate with others. Above all they share their faith in Jesus Christ, but they also share the wonder and order of God's creation.

Extension

Design a spacecraft which could land on the ocean of Oobleck. Students must take into account the properties of Oobleck when designing such a craft.

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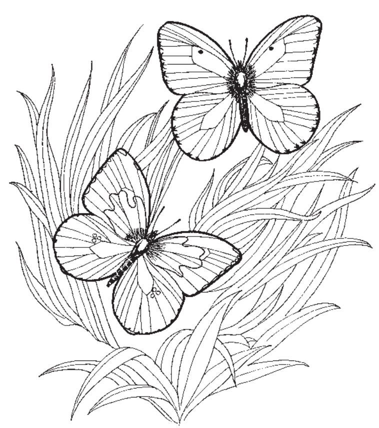


4. Popcorn by the Millions: A Lesson in Estimation

Equipment Needed

You will need unpopped popcorn (1 lb per 4 groups), Styrofoam cups to hold the popcorn before counting (one per group), at least one 100 milliliter (ml) graduated cylinder (a measuring cup for cooking could be substituted, but a narrow cylinder is more accurate), 5-gallon aquarium, and an air popcorn popper (optional)

Purpose

To understand the number million through the use of counting samples and estimating. (optionally, to compare the volume of unpopped to popped popcorn)

Safety—Special Considerations

Carefully supervise the students. (1) 100 ml cylinders have a high center of gravity with a small base and can be easily tipped over. Plastic cylinders are preferred. If you have glass cylinders, have the students measure the popcorn first and then count it. The cylinder can then be stored on its side. That is why they generally have hexagonal bases or attached hexagonal plastic protectors. (2) If an air popper is used, directions for the particular model of popper should be followed. Generally, the machine should be turned on before adding the popcorn. Also, the machine should be allowed to cool between runs or the heating filaments may burn out. Note that any unpopped seeds that come out of machine with the popcorn can be very hot. (3) Students should be warned against eating unpopped seeds. The hard seeds can damage teeth. A tooth may be chipped or a filling could be damaged.

Grade Level—Time Needed

Grades 4-7; Time: 20 minutes

Background

The concept of a million of something can be rather obscure. This activity will try to demonstrate this concept in a concrete way, possibly for the first time for the students. (Note: The amount of air space is not included in these activities, but that could be a whole different area to explore.) If you are uncomfortable using the metric system, converting to gallons is a possibility, but if the entire activity is done in the English system you will have to brush up on ounces, pints, quarts, etc. An easier method would be to work in metric and then to convert the final answer from liters to gallons. (Multiply the number of liters by 0.2642 to get gallons.) To actually have 1 million popcorn seeds you would have to buy about 240 lbs. The group working on this activity found that a volume of 100 ml had an average of 767 seeds of popcorn, so multiply by 10 to find the number in 1 liter (1000 ml). This makes 7670 seeds per liter. To find the number of liters for 1,000,000 seeds, divide 1,000,000 by 7670. The answer is 130.4 liters (or 34.4 gallons). This would take about seven 5-gallon aquariums. Of course, you may not get the same number as the developers of this activity and still be correct (See sources of error below).

This activity will correlate very well with math lessons that deal with direct proportions. This mathematics is crucial to success in high school chemistry. Using the figure of 767 seeds/100 ml, we would write:

$$\frac{767\ \text{seeds}}{100\ \text{ml}} = \frac{x\ \text{seeds}}{1000\text{ml}} \qquad \frac{7670\ \text{seeds}}{1\ \text{liter}} = \frac{1{,}000{,}000\ \text{seeds}}{x\ \text{liters}}$$

Note: 1000 ml = 1 liter

Here are a few more helpful hints. It may help students to think of a million as a thousand thousands. If they look at the number, they can see that this is true.

Students should always estimate what a reasonable answer would be for the calculation they are making. This is especially true when using calculators. The ability to estimate and the habit of using the estimate are major learnings for life. Education must change behavior.

Students may ask why popcorn pops. Popcorn has a strong, tight seed coat. The seed pops because of water that is stored inside. When the seed is heated, the liquid water turns into gaseous water which at normal pressure occupies about 1000x more volume. The hard seed coat resists such an increase in volume. So the inside pressure builds up until the coat suddenly breaks, and the seed explodes. If the gaseous water leaks out slowly, then the seed will not explode.

Procedure

On the floor or at a table, each group of 2-3 students should obtain about a Styrofoam cup (6 oz.) of seeds. More can be given later as you monitor the group's progress. As the students count seeds, they could choose to do this in one of two ways: either count seeds as they fill the cylinder to 100 ml , or fill the cylinder to 100 ml and dump the seeds out to count. The latter method is preferred if the cylinders are glass (see safety section) or the number of cylinders requires sharing them. Shaking the cylinder will help the seeds to pack in and result in less air space. Record the final amounts from each group on the board. The counts are likely to vary from group to group.

The aquarium can be used as a collection point and one student could act as monitor to keep a tally of the number of 100 ml loads dumped.

When each group has figured out how many seeds it takes to occupy 100 ml, the numbers on the board should be averaged to find the best amount. The teacher can ask, Why aren't the amounts exactly the same? (There are at least two major sources of error. The seeds may pack differently in the cylinder. The seeds from a package may also vary in size. Different types, white/yellow, and brands of popcorn may also vary in size.) Teach the students that scientists typically have to work with results that vary. They may ignore any numbers that seem to be very far off and will average those that are close to each other. Using the average number they will now be able to calculate how much space 1,000,000 seeds would take up.

How many seeds are in the aquarium so far? (Multiply the number of groups times 767 seeds) *What volume does that represent?* (Multiply the number of groups times 100 ml) *Can you estimate how many more aquariums it would take to hold a million seeds?* (You might want to place a convenient number of seeds into the aquarium.) They will likely guess between six to eight aquariums. This is correct. A mathematical approach predicts about seven aquariums (34.4 gallons / 5).

Assignment

Students could be asked to try the same activity with other uniformly sized small objects, for example, aquarium gravel, corn, soybeans, wheat, buttons, sand (for older students).

Ask students to plan how they would determine the area that would be occupied by a million blades of grass. (They could count a hundred blades and measure the area. If they multiply by 10,000, they would be estimating the area that a million blades would occupy. Another solution would be to count the number of blades in a square foot or a square metric area such as 10 cm x 10 cm. Then they could figure out what part of a million they have counted and multiply it by the inverse to get the area occupied by a million.

To really challenge students, ask them to find a million of something (anything) and prove it by explaining the strategy they used.

Christian Application

Consider that the number million is hard to visualize, and then consider that the Lord produces millions upon millions of popcorn seeds every year, not to mention the creative power of making millions of stars, billions of grains of sand, etc. We believe that each one of us is one out of seven trillion different children our parents could have had. We also believe that only 18 ml of water equals 6 x 10^{23} molecules. Recall the Bible story where God asks Abraham to count the stars (Ge 15:5). Truly, we have an awesome God!

Extension

How many popcorn seeds would it take to fill other containers, such as a gallon jar, garbage can, water tank of a fire truck, farm silo, or a lake? Use your imagination and think of others if you like. Another idea could be comparing the volume of a million of some other small object and the volume of one million popcorn seeds. If you have an air popper: repeat activity above with popped corn to show the dramatic difference of volume change. One could also ask if the chain link fence on the school grounds has a million holes in it.

Devito and Krockover have an exercise on estimating in their fine science activity book. They suggest asking students to guess how many raisins are in a box of raisin bran, how many chocolate chips are in a bag of chocolate chips, how many leaves are on one tree in your yard, how many cars are in a parking lots, how many floor tiles are on the classroom floor, or how many hairs are on a head. The possibilities are endless.

Related Children's Literature

An interesting picture book is *How Much is a Million?* by David M. Schwartz. The text and pictures try to help conceptualize a million, a billion, and a trillion.

References

DeVito, Alfred and Gerald H. Krockover. *Creative Sciencing*. Boston: Little, Brown, 1980, 220.
Schwartz, David M. *How Much is a Million?* New York: Lothrop, Lee & Shepard Books, 1985.
Schwartz, David M. *If you made a Million*. New York: Lothrop, Lee & Shepard, 1989.

RW and LR

“*The ability to estimate, and the habit of using estimating, are major learnings for life.*”

5. Hot and Cold Running Thermometers

Equipment Needed

Either a Fahrenheit (F) and Celsius (C) combination thermometer or two separate thermometers per group, (Combination thermometers are about $4.00 each, single scale thermometers are about $3.00 each.), stirring rod or spoon, 2 Styrofoam cups per group, hot water, ice, salt, paper towels

Purpose

To discover the relationship between the Fahrenheit and Celsius temperature scales, to familiarize students with the use of Celsius, to practice comparative and estimating skills relating to temperature, to teach students to manipulate thermometers correctly

Safety—Special Considerations

(1) Anticipate spilled hot water. Remember that if very hot water (very hot coffee) is spilled on clothing in contact with the skin, serious burns may result depending on the amount of water and the temperature. First aid for burns is cold water. Keep the warmest water handled by students near, but below 50°C. (2) Do not allow the students to estimate the temperature of any hot water by actually touching it. Teach the students to estimate the temperature of an object by approaching it with the back of the hand. If the student feels heat, the student should not attempt to touch or hold the object. (3) Anticipate breakage and use thermometers filled with colored alcohol, not mercury. Mercury freed from a thermometer is a poison. It evaporates and can be readily taken into the respiratory system. It can also be absorbed through the skin and should not be handled. (4) Teach students not to stir with a thermometer. Stirring may break the off bottom.

Grade Level—Time Needed

Middle to upper grades; Time: 20 minutes

Background

Gabriel Daniel Fahrenheit, a German physicist (1686-1736), developed his temperature scale using the coldest temperature he could get with a salt and ice water mixture as 0°F, and normal human body temperature as 100°F. We now know that normal human body temperature is about 98.6, so he erred a bit. Then he divided the space between into 100 equal spaces. This resulted in water freezing at the familiar 32°F, and the boiling point of water at 212°F.

Anders Celsius, a Swedish astronomer (1701-1744), thought that basing the temperature scale on water was a better idea. So he used the boiling point and the freezing point as the main references. Interestingly, he originally planned to put the boiling point of water at 0°C and the freezing point at 100°C, the reverse of what we have today. Others liked the idea of using water (because it is so common) but thought that the direction of the numbers should be changed around. The resulting scale, the centigrade scale (It has been renamed the Celsius scale to honor the inventor.) is part of the metric system and is widely used by the scientific community.

Lord William Thomson Kelvin, a British physicist (1824-1907), devised a scale that predicted the coldest possible temperature. This coldest possible temperature, the temperature at which no energy can be taken from a substance, is called absolute zero. Scientists believe that it is impossible to reach absolute zero (although experiments have been quite close to it). Absolute zero is equal to -273.15°C, and would be written as 0 K or 0 Kelvin. Degrees on the Kelvin scale are the same size as Celsius degrees which makes conversion a matter of adding 273 degrees to the Celsius measurement to change it into Kelvin. So water freezes at 273 K, and water boils at 373 K.

To convert from Fahrenheit to Celsius start with the Fahrenheit temperature, subtract 32, multiply by 5 and divide by 9. To convert from Celsius to Fahrenheit start with the Celsius temperature, multiply by 9 and divide by 5, and add 32. It just happens that -40°F is equal to -40°C on the two scales.

Teachers should keep in mind that temperature is only one aspect of the amount of heat contained by an object. Temperature and heat are not the same thing. To illustrate, it takes twice as much heat to bring two grams of water to the same temperature as one gram of water. The type of material being heated is another factor. Equal masses of metal and water at the same temperature would have different amounts of heat. The metal contains less heat. (A way in which we express this phenomenon is to say that metal heats up faster than water.) Every material has a specific heat. Water is given a value of one. That is, it takes one calorie of heat to raise one gram of water one degree Celsius.

Procedure

Arrange students into groups of 2 or 3. If you are using two separate thermometers, take the measurements at the same time.

- ◆ Fill a cup with water from the tap and set aside for measurement in step 6 after it reaches room temperature. This water could be set aside well before the class begins.
- ◆ Provide $^{1}/_{2}$ cup of the hot tap water available to each group. Be careful, some water heating systems in schools and homes have the water hot enough to scald a person. Have students record their estimates of the temperature in both F and C columns. Quickly after, carefully measure the actual temperatures and record in the appropriate F and C columns. Teach students not to stir with a thermometer. Stirring may break the off bottom. Save this water for step 3. (If you wish to also estimate and record data for very hot water such as over 50°C, do it as a teacher demonstration.)
- ◆ To the water from step 2, add one ice cube. Stir (not with the thermometer) until the cube is completely melted. Have students record their estimates of the temperature in both F and C columns. Quickly after, measure the actual temperatures and record in the appropriate F and C columns. Pour off some of the water until $^{1}/_{2}$ of water remains. Save this water for step 4.
- ◆ Using the water from step 3, fill the cup with ice and find the coldest temperature. You may need to pour off some water so a large amount of ice remains in the water-ice mixture. Have students record their estimates of the temperature in both F and C columns. Quickly after, measure the actual temperatures and record in the appropriate F and C columns. Save this water for step 5.
- ◆ Depending on the purity of the water, the coldest temperature from step 4 will probably be around 3°C. To this water now add 1 or 2 teaspoons of salt and mix thoroughly. Have students record their estimates of the temperature in both F and C columns. Quickly after, measure the actual temperatures and record in the appropriate F and C columns.
- ◆ Using the room temperature tap water, have students record their estimates of the temperature in both F and C columns. Quickly after, measure the actual temperatures and record in the appropriate F and C columns.

	Estimate Fahrenheit	Actual Fahrenheit	Estimate Celsius	Actual Celsius
1. hottest	________	________	________	________
2. warm	________	________	________	________
3. ice	________	________	________	________
4. salt/ice	________	________	________	________
5. room	________	________	________	________

Questions following the activity.

1. *Which of your estimates was most accurate?*
2. *Which of your estimates was least accurate?*
3. *In which scale was it easier to estimate? Why?* (We are more familiar with the Fahrenheit scale. If we used the Celsius scale every day, we would be better at estimating with it.)
4. *Why do scientists use C rather than F?* (Most of the world uses the metric system. The United States and Burma are the only countries left to still use the English system. The metric system is very convenient because it uses decimal relationships. All units are related to other units by powers of ten. The prefixes also indicate the size of the unit. Science is done all over the world; it is an international activity. So all scientists including those in the United States report all their work in metric. Some day the United States may change its common use of the English system.)

5. *Have you ever seen the C scale used? Where?*

Assignment

Report on the lives and works of Fahrenheit, Celsius, and Kelvin. Construct a comparative chart or table showing their three temperature scales with landmarks such as the boiling point of water. Perhaps the bulletin board could be used.

Find out how the temperatures of very hot objects are measured.

Write a five-paragraph theme on why the United States should (or should not) go totally metric. The first paragraph should state the problem and what you think the United States should do. Each of the next three paragraphs should support what you think the United States should do. The last paragraph should summarize your argument. This assignment correlates with language class.

Christian Application

The creation is filled with wonders that declare the glory of God. God has given us the ability to make devices like thermometers to study his creation.

Extension

Have students analyze the formulas for converting between the temperature scales. Can you understand why the formulas are written as they are? How are the C and K scales aligned so that zero on one scale means the same temperature on the other scale? How are different degree sizes handled?

Have students find the temperatures of various phenomena. Some examples of what they might find follow. All liquids and solids are broken up into gases at 4300 K. The surface of the sun is believed to be 6000 K. The surface of a hot star is 20,000 K. The center of the sun is 20,000,000 K. The center of an exploding hydrogen bomb is estimated to be 100,000,000 K.

References

Boehlke, Paul R. "The International Practical Temperature Scale is Established." *The Twentieth Century: Great Scientific Achievements.* Pasadena: Salem, 1994, pages 847-849.

MacDonald, D.K.C. *Near Zero.* Garden City, New York: Doubleday, 1961.

RW and LR

6. Dating Objects

Equipment Needed

Four sets of objects having different ages
- Set A: Attic Objects: dated mason jar, US $1 bill, copyrighted book, canceled check
- Set B: Coins: CSA replica coin, US coin with date worn off, foreign coin, US coin
- Set C: People in pictures: pictures of baby, child, teen, adult
- Set D: Earth objects: quartz crystal, amber with insect inside, fossil, limestone

(Substitutions can be made.)

Purpose

Students will see how scientists come up with relative dates for various objects. (1) They will discover that assumptions must be made when dating objects. (2) They will discover some of the general principles that are applied in the dating process. (3) They will discover that appearances may be deceiving when dating objects.

Safety—Special Considerations

Caution student to handle the objects with care.

Grade Level—Time Needed

Junior high and high school

Background

A person cannot reason without making assumptions. If the assumptions are false, the conclusions are likely to be wrong. The important thing is to encourage students to recognize their assumptions and the fact that others are also making assumptions.

When people observe an object, they often try to determine its age. This human habit of dating objects also includes scientists who may look for evidence of very old ages to support the evolutionary concept that things change slowly over long periods of time. Working with various common objects in this activity will help demonstrate the difficulties of arriving at relative ages for objects. The process of dating clearly includes preconceived ideas about how to date objects and necessitates making assumptions in order to proceed.

Christians also need to remember that on each day God created a good and complete creation. Adam, Eve, and many things in the Garden of Eden had the appearance of age as they were made. No doubt most of creation also necessarily required a built-in age in order to be functional. For example, stars with light already reaching the earth was part of the completeness. In all these cases reason alone would argue for long ages that never were.

Procedure

A. Pre-lab discussion
   1. Discuss freshness dates found on food products in grocery stores.
   2. Discuss some assumptions people may make when guessing other people's ages.
   3. Discuss why dating objects, such as photographic film, may be important.

B. Lab
   1. Examine each of the objects in Set A.
   2. Attempt to organize the objects in Set A according to their relative ages, from oldest objects to youngest.
   3. Return the objects to Set A.

> "Reason is our servant and not our master."

4. In turn, examine each object in the other three sets and also organize and record the information in the data table as was done with Set A.
5. Return all objects to their respective sets and return the sets of objects.

C. Post-Lab

1. List the reason(s) for assigning each object in the various sets the relative ages that were given to them.
2. Exchange your list of reasons with another person and discuss the merits of the reasoning used by each to assign relative dates to the objects in each set.

Data Table

Object Set	oldest			youngest
A				
B				
C				
D				

Assignment

Have students do the work sheet.

Christian Application

- ◆ Discuss the student answers to Assignment question #4 and contrast them with the reasons an evolutionist might have for dating objects, the earth, or the universe.
- ◆ Discuss how human reason may produce different answers to Assignment questions #1 and #2, but may nevertheless be "relatively true" for each person answering.
- ◆ Discuss the role of human reason in understanding and interpreting the Scriptures. While it is true that we are thinking beings, students need to know that there are many things we do not know and cannot answer. We must trust God and not allow reason to make us doubt God's Word. Reason is our servant and not our master.
- ◆ List the class responses to Assignment question #5 on the board and discuss the merits of expert testimony in dating objects.

Extension

- ◆ Research and report on the techniques of radioactive dating methods.
- ◆ Research and report on the dating of the Shroud of Turin or Antarctic seals (Cf. "Strange Seals" by Martin Sponholz following this activity).
- ◆ Research and report on the techniques of dating the universe.
- ◆ Research and report on how the various evolutionary theories of gradualism, catastrophism, and punctuated equilibrium can skew the dating process.

References

Becker, Siegbert W. *The Foolishness of God: The Place of Reason in the Theology of Martin Luther.* Milwaukee: Northwestern, 1982.

PW

Lesson 6 Worksheet

Name ______________________________

1. What assumptions were made when assigning relative dates within each set of objects?

   a) Set A ______________________________

   ____

   b) Set B ______________________________

   ____

   c) Set C ______________________________

   ____

   d) Set D ______________________________

   ____

2. Explain how the appearance of maturity influenced assigning relative ages in Set C.

3. Explain how the assumptions of a Christian and a non-Christian may differ in the dating processes used with Set D.

4. Why is the age of the earth or universe not as important to a Christian as it might be to an unbelieving person?

5. Often experts are called in to assist in determining the age of an object. Circle the person whom you would choose to assist you in assigning relative dates to each set.

a) Set A:	historian	home owner	librarian
b) Set B:	numismatist	metallurgist	counterfeiter
c) Set C:	genealogist	photographer	relative
d) Set D:	geologist	paleontologist	gem expert

Strange Seals

Martin P. Sponholz

One of the summers I was in Antarctica as a research scientist for the Atmospheric Resources Laboratory of our government, a large number of mummified crabeater seals was found. They were intensely studied where they were discovered, in the dry valleys of southern Victoria Land. The first of such mummified seals were discovered by the British explorer Captain Robert F. Scott on his first expedition of 1901-1904. The bodies of the seals had been preserved in the cold, dry climate. Since then more than 300 seal carcasses have been discovered and the position of each discovery has been carefully recorded and mapped.

The event of animals dying in the wild is not strange and rarely merits such careful research. However, these seals died forty miles inland, away from the ocean coast, away from the crabeater seal's food supply. They also died at an elevation of 4000 feet above sea level. Legless seals are not climbers. Many of the seals were young pups; some may have been newborn. How did they get so far and so high above their habitat?

Some field scientists suggested that these dead seals may indicate an ancient coast line. Hence, radiocarbon analysis (carbon-14 dating) was used to determine the time of the death of the seals, but these data yielded a strange variety of answers ranging from 615 to 4600 years ago.

Facing somewhat unacceptable results, research often pursues a radical method. The principal investigator decided to kill a live crabeater seal living along the present day coastline near McMurdo. Carbon-14 dating techniques were put to the test with the freshly-killed seal and gave an incredible answer. The McMurdo seal had carbon-14 concentrations in its body equivalent to an organism that had died 1300 years ago.

As a scientist doing atmospheric research on the ice, I was personally troubled by much of the evolutionary findings of my colleagues at that time. Upon hearing the preliminary reports, I smiled and returned to launching my research balloons. It is in nature, the laboratory that our Lord maintains, where human ideas are put to the test. It is humbling to face the witness of nature. Our Creator indeed is subtle. For all of us it remains a comfort that "words which You Yourself shall give me must prevail" (*Christian Worship*, #446).

Picture: Cover, *Antarctic Journal of the United States,* Published jointly by Office of Polar Programs, National Science Foundation, and U. S. Naval Support Force, Antarctica, Department of Defense, VI (September-October): 5, 1971.

Wakefield Dort, Jr., "Mummified Seals of Southern Victory Land," *Antarctic Journal of the United States*, VI (September-October): 5, 1971, pages 210-211.

7. Investigating Magnetism

Equipment Needed

Various materials to be tested for magnetism

Set A: Household objects: marble, key, wood block, string, nail, screw, plastic pen cap, cloth strip, golf ball, pencil

Set B: Screws: five bent brass screws and five straight steel screws painted alike

Set C: Metals: aluminum, bismuth, cobalt, copper, magnesium, nickel, wood's metal, tin; electronic balance, coil of copper wire, RCS cell, alnico magnet, neodium alloy magnet, masking tape

Purpose

To discover how scientists work: (1) to investigate the phenomena of magnetism using the scientific method, (2) to test the principle that metallic objects are attracted by magnetism

Safety—Special Considerations

Safety considerations and special announcements: Be sure to disconnect the electromagnet immediately after each use in order to preserve the cell.

Grade Level—Time Needed

Junior high and high school; Time: 30 minutes

Background

When scientists explore God's creation, they use their gifts of reason and their powers of observation. Francis Bacon (1561-1626) wrote that once a problem has been formulated, it is best solved by observing, forming a hypothesis, testing the hypothesis by experiment and then reaching a general conclusion. Bacon's scientific method will be used in this investigation to explore the phenomena of magnetism and to test the principle that metals are attracted by magnetism.

Procedure

A. Initial investigations
1. Scatter the objects in Set A onto a table top or laboratory bench.
2. Using the alnico magnet, touch each object in turn and observe whether or not it is attracted to the alnico magnet. Record your observations in Data Table 1.
3. Replace Set A with Set B and again use the alnico magnet to test each object.
4. Record your observations in Data Table 1 and return the sets of objects.

Data Table 1

	objects attracted by magnet	objects not attracted by magnet
Set A		
	______________________	______________________
	______________________	______________________
	______________________	______________________
	______________________	______________________
Set B		
	______________________	______________________

B. Further Investigations:

1. Tape the neodium magnet to the pan of the electronic balance and use the TARE control to zero the balance.
2. Without touching the magnet, use each of the objects of Set C in turn to approach the magnet from above. It may be necessary to come within a few millimeters of the magnet with some objects.
3. Record in Data Table 2 the objects that are nonmagnetic (the balance remains at zero), magnetic (the balance reads negative), or diamagnetic (the balance reads positive).

Data Table 2

nonmagnetic	magnetic	diamagnetic

4. Place the copper coil of wire 6 cm. above the magnet and connect its leads to the RCS cell. Now reverse the connections and record your observations.

Assignment

1. Which household objects are generally attracted to a magnet?
2. Explain the behavior of the screws in Set B.
3. Does Part A, Initial Investigations support Objective #2?
4. After doing Part B, Further Investigations, rewrite Objective #2.
5. What form of energy appears to be related to magnetism?
6. Define: diamagnetism, ferromagnetism, and paramagnetism.

Christian Application

Science uses inductive reasoning to arrive at general conclusions from a few specific observations. This method is often used to gain useful knowledge of the world in which we live. Nevertheless, sure truth can only be found in Scripture, and this cannot be proven or disproven by science. Even the pagan philosopher Aristotle (384-322 BC) cautioned science about using the inductive method of reasoning. He preferred the deductive method in which a few specific statements can be made from a general conclusion known and accepted by all. In its use of inductive reasoning, science has changed over the years replacing facts, concepts, and laws with newer, "improved" ones. We must recognize that science claims it knows more than it can know.

Extension

1. Research and write about the Curie point, the magnetic domain theory and magnetic monopoles.
2. How does a modern application of what was observed in Procedure B(4) permit the existence of the technological culture of the world we see today?

PW

8. Summary: Scientific Methods

Equipment Needed

Chalkboard or chart paper and markers

Purpose

To review and summarize the previous activities on how a scientist works

Safety—Special Considerations

None

Grade Level—Time Needed

Varied, adaptable; Time: 20 minutes

Procedure

Write the following headings across the board or chart: “Laboratory,” “Convention,” “Spacecraft Design.” Ask the students to describe how they acted like scientists in the laboratory exercise with Oobleck. *Can we make a list of things that scientists generally do?* List those ideas on the board as the students give them. Do the same for the other categories: “Convention” and “Spacecraft Design.” Ask: *Are scientists ever influenced by other ideas or by what they expect to see? Is doing science good? Are scientists always correct? What does the study of nature tell us? How has science helped you?*

Science is both product (knowledge) and process. Scientific knowledge is not useful unless the process by which it was gathered is understood. Product and process should not be separated in science education. Literacy includes knowing both. The process of doing science includes observing, describing, comparing, predicting, separating, measuring, classifying, identifying, estimating, using numbers, inferring, forming hypotheses, recording data, controlling variables, graphing, experimenting, building models, communicating, debating, explaining, and being ready to change ideas. The students should be able to list many of these as things that scientists do.

Background

Scientists are not objective and may jump to conclusions. They are greatly influenced by assumptions and the science that has already been accepted. All people tend to see what they expect to see. Science is a human activity and is subject to human error and limitation. When science concludes that we have evolved by natural processes from chemical to mankind and were not created, it is wrong. This is a limitation of science; it can discover only natural causes. Nevertheless, in many other areas of science God blesses us greatly through discoveries that often lead to greater appreciation of the Creation and also to technologies that enhance our lives.

Assignment

Report on how people behave as scientists in daily life. See “Possible family involvement.”

Family Involvement

Observe and discuss how people behave as scientists in daily life. Make a list of how each family member works as a scientist.

Christian Application

This activity gives structure to the joy of investigation and discovery of God's world. It encourages students to use science to the glory of God. The processes of science are gifts of God that enable us to study nature. The study of nature shows us that God created a wonderfully complex universe. These wonders are more than we can fully understand (Job 38).

Extension

See Asimov (1972) and Moulton (1960).

References

Asimov, Isaac. *Asimov's Biographical Encyclopedia of Science and Technology.* New York: Doubleday, 1972.

Moulton, F.R. *The Autobiography of Science.* New York: Doubleday, 1960.

Sneider, C.I. *Oobleck: What Do Scientist's Do?* Berkeley, California: LHS Gems, Lawrence Hall of Science, University of California at Berkeley, 1985.

DF

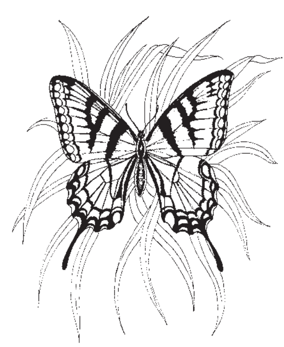
"*Scientific knowledge is not useful unless the process by which it was gathered is understood. Product and process should not be separated.*"

A Simple Truth

In the entire sphere of human learning the relation of reason and revelation is most confused. The use of reason does not go farther than human experience. Revelation, on the other hand, goes beyond the sphere of the human. Reason does not bring us to Christ, but only farther away from him. C.F.W. Walther said, "He who would add the light of his reason to the light of Scripture in order to make that brighter is as foolish as the man who holds a candle aloft so that I might better see the sun."

The idea that we must use our finite reason to grasp the infinite is an entirely mistaken notion. To be sure, we are to use our reason for such problems which involve knowledge related to the physical world. But to find information concerning our relation to God, we must turn to the Bible. Reason is the basis of science, but revelation is the foundation of religion—a simple truth, and yet how hard for the egotistical pride of man to understand and accept.

Arnold J. Koelpin



Doing science includes —

observing
describing
comparing
prediction
separating
measuring
classifying
identifying
estimating
using numbers
inferring
forming hypotheses
recording data
controlling variables
graphing
experimenting
building models
communicating
debating
explaining
being ready to change ideas

1. Can You Keep the Paper Dry?

Equipment Needed

A small drinking glass (or small jar of any type), large clear glass container (wide mouth gallon jar, aquarium, or similar-sized container), a partial piece of crumpled paper (tissue, paper toweling, or even newspaper), water for large container (one set of equipment if done by one volunteer student or as teacher demonstration; could also be done in several small groups)

Purpose

Air exists, even though it is invisible. Containers that appear empty are actually filled with air; air takes up space and can be compressed.

Safety—Special Considerations

Wet jars or containers are easily dropped! Use plastic containers. Do not attempt to move a larger, heavy aquarium (larger than 5 gallons) once it is filled with water. This may damage the seal between the glass walls and cause leakage. Hardware stores sell fairly large plastic containers for storage that could be substituted for an aquarium. Secondly, the difficulty of moving a large, filled aquarium and compensating for the water's inertia may cause spillage.

Grade Level—Time Needed

Grades 3-8; Time: five minutes (longer for greater discussion or extensions)

Procedure

Before class add water to a large container/aquarium leaving it about one-fourth empty in the event of splashing. Show the "empty" small drinking glass/jar to the class and ask, *What is in the glass?* The wrong answer of "nothing" would be preferred at this point, but if someone suggests that air is in the jar, answer with, *Keep that in mind.* Crumple the paper and stuff it into the bottom of the glass so it stays in the bottom even if the glass is tipped upside-down (teacher or student can do this). Challenge the student(s) to come up with a way to plunge the glass containing the paper into the water without getting the paper wet. (Students could put their hypotheses on the board and/or write down their observations as they test each guess.) Discussion: *How many hypotheses worked? Can you explain how it worked? What does this experiment show about air?*

Background

If the glass is held upside down and plunged into the water, the paper will not get wet. It can be kept there for some time so students can observe. The glass must be lifted out the same way it was put into the water. It must be kept perfectly straight when this is done. Water could not get into the glass because it was filled with air; the air cannot get out and air takes up space. Even though it is less dense than the water, the air remained in the glass because it is contained by it. Air can be compressed, if it cannot escape. Compression of air can be seen if careful observation is done as the inverted jar is slowly put under water. A small amount of water will enter the jar—compress the air—and then stop when the air is able to equal the pressure of the water. Machines called compressors can force a large amount of air into small, strong steel cylinders. This compressed air can then be used to do many things, such as inflating tires, providing power to operate pneumatic drills and hammers, and pressurizing the cabins of high-flying airplanes. Compressed air is also used to bring submarines back to the surface.

Assignment

If this is the first day of a unit on air, an assignment could be to list ways in which air is used to do work in life, or to research what air is made of (Also see extensions, below). Concepts listed above under "Purpose" could be put into the student's notebook for a later reference and testing.

Family Involvement

Students can easily repeat this at home, challenging family members, then explaining the concepts.

Christian Application

1) See Colossians 1:16. "For by him all things were created: things in heaven and on earth, visible and invisible … and in him all things hold together." 2) This lesson on air can remind us of God's love in that both are invisible, but absolutely necessary for us. However, in heaven we probably won't need air, but we will be able to enjoy God's love to the fullest.

Extension

1) What might happen to the inverted glass if it were pushed down 10 feet under water? 1,000 feet? The farther down the glass is pushed into water, the more the air is compressed, which results in more water entering the glass. At some point the glass will most likely shatter. Ask students to find our what the pressure of water is as an object goes deeper and deeper. 2) Do the procedure again, but this time use a paper cup to demonstrate that air is trapped in the glass. Use a nail/pencil to poke a hole in the bottom of the cup. Invert the cup, holding your finger over the hole. Push the cup to the bottom, remove your finger from the hole, and observe. The water will enter the cup, forcing the air out the hole in the bottom of the cup. Bubbles of air will be seen rising to the surface. 3) When people have to work under water, they can be inside a container with air in it or pumped to them. Divers can leave a submarine through a hole in the bottom of the sub that is open to the sea just like the hole in the bottom of the glass.

Matter can be defined as that which has mass and takes up space.

For every 34 feet below the surface of water the pressure increases one atmosphere which is 14.7 pounds/square inch. So if a person were under the water at 68 feet below, there would be a total of three atmospheres of pressure on the body: one for the air pressure and two for the water.

References

AIMS Newsletter. April 1988.
Liem, Tik L. *Invitations to Science Inquiry*. (2nd ed.) Lexington, MA: Ginn Press, 1981, page 8.

KL

"For by him all things were created: things in heaven and on earth, visible and invisible...and in him all things hold together."

2. Air, Air—It's Everywhere

Equipment Needed

One medium-sized plastic garbage bag, one plastic sandwich bag per student

Purpose

To learn that air is all around us and takes up space

Safety—Special Considerations

Announce that you will allow the students to pop the bags today as part of the science investigation. Normally, this is not allowed because it could disturb studying or scare someone. Tell them not to do it until you tell them at the end of the lesson.

Grade Level—Time Needed

Grades K-6; Time: a few minutes

Background

Air is found everywhere on the surface of our planet. The bags could be inflated by blowing, but then they would contain exhaled air, which has a greater percentage of carbon dioxide and more water vapor. When slammed between two palms, a bags will burst with a loud pop. The explosion is caused by the sudden expansion of the air rushing out of the torn plastic bag. An example, of course, is a popping balloon. In outer space, sounds cannot be transmitted because there is no air to carry them. Sound must be transmitted through matter.

Procedure

The teacher should take the medium-sized garbage bag, open its mouth, show the students, and ask, *What's in the bag?* The likely answer will be that the bag is empty. Move the open bag with two hands to capture air, then quickly close the mouth of the bag. Ask: *What do I have in the bag now?* Next hand out a small sandwich bag to the students and tell them try to catch air—without blowing into the bag (blowing brings up other ideas; if you'd care to bring them in, allow blowing). Questions: *What is filling the bags? Can we catch air under our desks or behind the piano? Is air everywhere?* (everywhere on the surface of the earth) *What would happen if we hit the inflated small plastic bag with the palm of the other hand? What makes the noise?* (the escaping air)

Optional for older students: *How else can we fill the bag?* (blowing*) Would the material in the bag be the same if we blew in it?* (No, it would have less oxygen, more carbon dioxide and water vapor.) Tell students that air is a mixture of gases including nitrogen, oxygen, carbon dioxide, water vapor and some other gases.

Assignment

If the optional procedure is followed, this assignment can be made. Tell students to inform their parents about this experiment before doing it. Tell them to exhale (blow) air into one sandwich bag, and trap a sample of air in a second bag. Twist the bags shut as the samples are taken, tie both with twisties or string, and place them into the freezer. After a few minutes examine them. Are there signs of water vapor? (Condensation should occur in the bag with exhaled air. It may even occur as the person exhales without using the freezer. The bag will no longer be clear but will appear cloudy. The bag with trapped air may or may not have condensation depending on the humidity in the home. Winter air in heated homes often does not have much water in it.)

Have students report on what they find.

Family Involvement

Students can review the entire lesson with their parents and older students can do the assignment at home.

Christian Application

"Who has given us the air?" "Is there air in outer space? (no)" Air with oxygen in it is needed for most life. God has given us plants that use sunlight to make oxygen for us to breathe. We exhale carbon dioxide which is used by the plants to make them grow. Plants are food for us and other animals. Without plants we could not live. The air would not have enough oxygen, and we would run out of food. We need to realize this and take care that we do not destroy plants. The rain forests and ocean plants produce most of the oxygen on the earth.

Extension

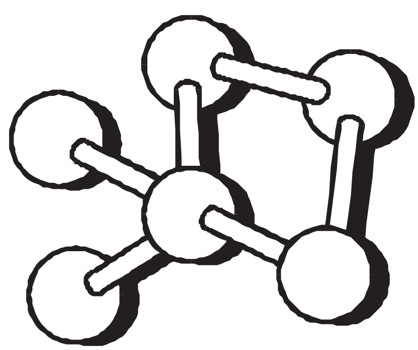
Assign a student to find out where most of the earth's oxygen comes from.

References

Liem, Tik L. *Invitations to Science Inquiry.* (2nd ed.) Lexington, MA: Ginn, 1981, page 5.

KL

"*We need to realize this and take care that we do not destroy plants.*"



3. Pull the Bag In...Pull the Bag Out

Equipment Needed

One or two plastic sandwich or bread bags (with openings wide enough to fit over jars), one or two large wide-mouthed jars (or plastic one-gallon container, or coffee can), masking tape and/or strong rubber bands

Purpose

To learn that air exerts pressure; pressure increases when volume decreases

Safety—Special Considerations

In the extension, do not heat glass that is not Pyrex. Do not heat the balloon with an open flame. Remember that hot glassware does not look hot. Bread bags are made of thin plastic and rip easily. Have extras available, check for holes, and tape holes with masking tape if necessary.

Grade Level—Time Needed

Grades: 5-8; Time: ten minutes (or longer if there's more discussion, or the extensions are done)

Background

In procedure one, the bag is secured to the jar with both the jar and the bag filled with air. Because the space is already filled with air, the bag cannot be stuffed into the can. In trying to push the bag in, the pressure increased (because the volume decreased) and this held the bag out. In procedure two, the bag is secured to the can after the bag has been pushed to the sides to eliminate as much air as possible. The air outside exerts pressure, which is balanced by the air pressure within at the outset. Trying to pull out the bag expands the volume for the trapped air, thus lowering its pressure (Boyle's Law). This creates an imbalance between outside air pressure and inside air pressure which quickly becomes great enough to prevent removal of the bag. Normal air pressure at sea level is 14.7 pounds per square inch. Air pressure becomes less as one gains altitude. Air pressure also varies with the weather.

Procedure

Before putting the bag on the jar, show the bag and the jar and ask, *What is in the bag? What is in the jar?* (They probably know the correct answer is "air" before doing the activity, although students could be told later, too.) Invert the bag over the mouth of the jar, blow a little air in the bag so that the bag stays inflated over the jar. Seal bag over jar with tape and/or rubber band. Now ask a student to push the bag into the jar (without tearing it). (It won't work.) Ask: *What is holding the bag out of the jar?* Next, either take apart this set-up and reuse the bag and jar, or keep these together and use a second set: Place a plastic bag inside another jar and let the edge of the bag hang over the jar rim (like you would line a trash can; be sure to push all air out—perhaps without students noticing). Tape and/or rubber-band the bag securely over the jar rim. Ask a student to take the bag out of the jar (without tearing it or removing the tape or rubber band). (It will not work.) Ask: *What is holding the bag inside the jar?* (It is being held by outside air pressure.)

Assignment

(For older students) Normal air pressure at sea level is 14.7 pounds per square inch. Have students measure the number of square inches of bag surface and calculate the pressure on its surface.

Family Involvement

Students could do this at home, explaining the concepts to family.

Christian Application

God created a substance that we need to live, that, although unseen, can take up space and push against us and other objects.

Extension

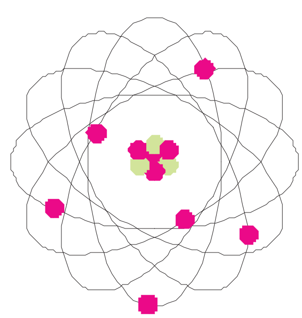
1) Ask: *What problem occurs (concerning air) when you try to fold up your camping tent, air mattress, or an inflatable water toy?* (Air is trapped inside, and unless you get it all out, your mattress, tent, etc. will take up more space when you try to pack it.) 2) When the bag is on top of the jar, try putting the jar into a larger container with ice. In winter in some states you could put the jar outside. The air will cool and occupy less space, allowing the bag to be stuffed in a bit farther. If you have a Pyrex flask, place a balloon on top of the opening. Heat the container with a hot plate; the air will expand and occupy more space which will inflate the balloon. You might even break the bag or explode it off the jar.

References

Liem, Tik L. *Invitations to Science Inquiry.* (2nd ed.) Lexington, MA: Ginn, 1981, page 6.

KL

“*What is holding the bag inside the jar?*”



4. Lifting Heavy Objects With Air

Equipment Needed

One or more plastic bags—bread-bag size or larger; two or three (text)books; optional: a light wooden board and a student to sit on it; a (light)table that can be lifted upside-down on top of another table; more large plastic (garbage) bags are also then needed

Purpose

To recognize that the pressure of gas (air) can move objects

Safety—Special Considerations

If attempting the optional table-lifting, students (or teacher) may breathe/blow too hard and get dizzy! Check that bags have no holes. Watch that tables being lifted do not slip off and fall.

Grade Level—Time Needed

Grades: 3-8; Time: five minutes (more if involving more students or doing options)

Background

There is a limited amount of space available in the plastic bag. As the air is blown into the bag, it exerts pressure on the inside surface. That pressure becomes greater than that pushing down on it from above, and the bag lift the book/person/table. Applications: Air jacks lift automobiles; air bags in automobiles prevent harm in crashes.

Procedure

(Student(s) or teacher) Place an empty bag on a table top with the opening toward the edge. Place one book on top of the plastic bag. Blow air into the opening of the bag (hold bag tightly over mouth). Observe. Let the air out of the bag. Add several books, one at a time. Try to lift them by blowing air into the bag. Have a contest—keep adding books, allowing various students to try. Ask: *What does this activity show about air?* (air exerts pressure)

Assignment

Students could brainstorm or research ways in which this concept does useful things (or incorporate this into the discussion and give no assignment).

Family Involvement

Students could do this at home and have fun while educating their family.

Christian Application

God has created a wonderful substance that we need to live, but it can also be used for getting work done (to his glory).

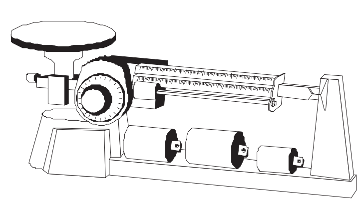
Extension

1) Put one or more bags under a small board; have students blow, trying to lift a classmate who is sitting on top the board. 2) Put many large garbage bags (ten or more, depending on size of table) with the ends out, around a table; put a second table on top, upside-down and on the count of three, everyone blows, seeing how far the group can lift the table. (This could be done with teams of students competing.)

References

Liem, Tik L. *Invitations to Science Inquiry.* (2nd ed.) Lexington, MA: Ginn, 1981, (has table option).

KL



5. The Straw Drinking Race

Equipment Needed

Two identical drinking straws (one punctured with a few hidden needle holes over the whole length), two small cups and some water (or soda/pop) to drink (more for more students to be involved and if you like to be very sanitary and not share straws or cups)

Purpose

To understand that the air around us is exerting pressure; that removing air lowers air pressure

Safety—Special Considerations

Do not allow students to share straws or cups for health reasons. If a colored liquid is used, the results are easier to see; using Koolaid or soda is a treat!

Grade Level—Time Needed

Grades: 4-8; Time: five minutes

Background

By "sucking" we are creating a lower pressure in the straw above the liquid that we drink. The higher pressure in the atmospheric air pushes the liquid up the straw into our mouth. A student with the leaky straw allows more air to enter, and therefore one cannot lower the pressure above the liquid. If there were no air pressure in the atmosphere, we would not be able to receive liquids through a straw. If the mouth of an astronaut was connected to a straw in an open cup with liquid on the moon's surface, he would not be able to drink the liquid by sucking through the straw, because there is no pressure on the liquid surface that will push it up the straw. Be sure to teach that we cannot "suck" liquids. A little joke that goes a long ways in science is "Nothing in science sucks."

Procedure

Put some liquid (halfway is fine) into the cups. Ask for participants in a "sucking race" and give each of them a straw (one with holes, one without—but don't tell! Put straws into soda-filled cups immediately before the start of the race, so participants don't have the opportunity to notice the holes in the straws). On the count of three, they should start sucking. Give another pair of students a turn to race. (The one who has the straw with holes always loses.) Discussion questions: *What makes the liquid go up the straw when we drink?* (Air pressure push the liquid into our mouth.) *Why is it so hard to drink through a leaky straw?* (The air pressure in the straw cannot be reduced.) *What do we actually create when we suck through a straw?* (lower air pressure—a partial vacuum) *Would we be able to drink through a straw if there was no air pressure around us?* (no) *Would an astronaut in space or on the moon be able to drink liquid through a straw?* (no)

Family Involvement

Do at home to educate your siblings or parents!

Christian Application

God has given humans great abilities to understand his creation. There are many everyday happenings that we seldom question or truly understand (such as what's really going on when drinking through a straw?) Continue asking how things work throughout your life, growing in your appreciation of the complexity of God's creation, His wisdom and awesome power.

Extension

Use two different liquids to introduce another variable (and to throw off the guesses for awhile).

References

Liem, Tik L. *Invitations to Science Inquiry.* (2nd ed.) Lexington, MA: Ginn, 1981, page 12.

KL

"

… we cannot 'suck' liquids

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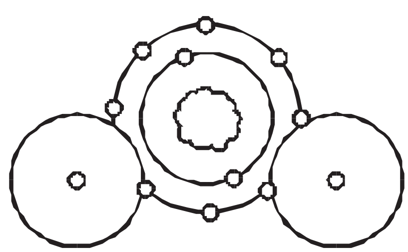


6. Egg in the Bottle, and Out Again!

Equipment Needed

One hard-boiled egg, with shell peeled (be sure egg has cooled thoroughly before attempting to peel); one quart-size juice bottle (larger gallon size wine bottle will work, too) with an opening of the size that the egg will rest on without falling in (choose the thinnest egg that will still rest in the mouth of the bottle—it's easier to get out later) (a small water-filled balloon, greased lightly, may be substituted for the egg); one piece of paper twisted or folded to fit into the jar; matches

Purpose

To demonstrate the force of air pressure and expansion of air when heated

Grade Level—Time Needed

Grades 5-8; Time: seven minutes or more (depends on length of discussion)

Background

The burning paper is heating the air in the bottle and expanding it; this is why the egg was vibrating before it was sucked into the bottle. Some of the air slipped past the egg as it left the bottle. Therefore less pressure was in the bottle. Note that one might think that an added cause for the decreased pressure inside the bottle is that the burning of the paper took away the oxygen of the remaining air, but this is replaced by carbon dioxide gas and water vapor. The vapor often can be seen as condensation on the inside of the cold bottle.

Procedure

Place the peeled egg (pointed end down) on the mouth of the bottle. Ask: *What will happen if I put a burning piece of paper in the bottle and put the egg back on the bottle?* (possible answers: The egg might jump off. The fire will go out. The bottom of the egg will get black. The bottle might crack, etc.) Light the piece of twisted paper, lift the egg up, put the burning piece of paper in the bottle, and place the egg immediately back on the bottle's mouth (the egg will get pushed into the bottle). Questions to ask at this point: *Why did the egg get pushed into the bottle?* (The greater outside air did it.) *What did the burning paper do to the air inside the bottle?* (expanded the air, causing some to leave the bottle) *What did the egg do before it went into the bottle?* (Careful observers will notice the egg move if air is still escaping the bottle) *How can we get the egg out of the bottle without cutting it up?* (Students will probably say 'suck it out'; let them try this, but it won't work!)

To get the egg out of the bottle whole: invert the bottle and let the egg fall into the bottle neck; blow a short spurt of air up into the upside-down bottle, and catch the falling egg!

Assignment

None (or, give extra credit if someone can figure out a different way to get the egg into or out of the jar. See extensions below.)

Family Involvement

Tell students to do this at home—with parental monitoring, since boiling an egg and using fire are involved. They must be sure to include the proper explanation for their family.

Extension

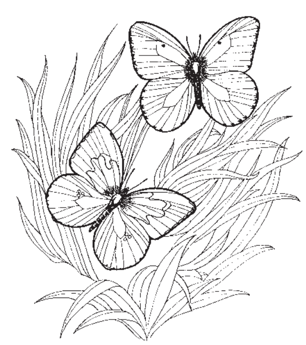
A cleaner way to get the egg into the bottle (but much slower) is to add hot water to the bottle (about three inches) and place the egg on top. Like before, the air in the bottle will eventually cool and create decreased pressure in the bottle. Another way to remove the egg after inverting the jar is to pour hot water on the outside of the bottle. This will create enough increased air pressure inside to force the egg out.

References

Liem, Tik L. *Invitations to Science Inquiry.* (2nd ed.) Lexington, MA: Ginn, 1981, page 30.

KL

“Why did the egg get pushed into the bottle?”



7. The Sticking Jar

Equipment Needed

A small jar: the "tall size" baby food jar (not a beaker, because of its pour spout), a small piece of paper, matches

Purpose

To demonstrate the force of air pressure and the expansion of air when it is heated

Safety—Special Considerations

This should be a teacher demonstration, due to the possibility of a burn! Keep the paper small and well-crumpled, so that it lands flat near the bottom and the flame is away from the skin. Be sure that your hand is wet. The partial vacuum will leave a red spot on the skin, which will disappear in a short time, depending on how long the glass has been left against the skin! If done on the palm, the red mark disappears quickly. Like all activities, the teacher should rehearse this before attempting it in the classroom.

Grade Level—Time Needed

Grades 5-8; Time: five minutes

Background

There was something in the jar at the beginning, and that was air. The burning paper inside the jar heated and expanded the air. This expanding air rushed out, and when the jar was quickly pushed against the forehead or palm, the jar was closed off from the outside air. This caused the flame to go out, since there was no more oxygen to feed the process. The extinguishing of the flame caused the air inside the jar to cool off and therefore to contract. The pressure inside the jar was therefore less than the atmospheric pressure outside the jar, and this higher air pressure held the jar against the palm. In other words, a partial vacuum was created inside the jar, which kept the jar against the skin surface.

Procedure

Show the jar is empty by inverting it. Wet your hand. Crumple a small piece of paper, light it on fire, and drop it into the jar. Flames should be well below the top of the jar. Immediately press the jar against the wet palm of your hand. (See warning above!) Keep pressing until the fire is out or until you feel a pressure change. When you feel a lack of pressure inside the jar, slowly let go of it—it will stay stuck against your palm. Be ready to catch the jar if it fails to seal or if the pressure difference is not great enough. Questions to ask: *What was inside the jar before burning the paper?* (air) *Why did the flame inside the jar go out?* (lack of oxygen) *What does the heat of the flame do to the air inside the jar?* (expand the air, causing some of it to leave the jar) *What was left inside the jar after the flame went out?* (less air than before) *What made the jar stick to the teacher?* (the larger air pressure on the outside) *Why did the teacher wet the hand?* (As long as the hand is wet its temperature cannot rise above 212 degrees F which is the boiling temperature of water. This protects against burns until the water evaporates.) Carefully explain that you have not created a suction inside the jar; you have lowered the air pressure inside the jar. To say it correctly, the jar is not sucked against the hand by lack of air inside; the jar is pushed against the hand by the outside air. Consider two people arm-wrestling against each other. If the stronger person wins, we would not say that the weaker person was causing a suction and is pulling the stronger arm down the field. Rather, the stronger pushes the weaker down because of the unequal forces.

If this demonstration is done several times without much time between trials, the jar may come warmer and warmer and be able to equalize the outside pressure with expanded air. The teacher could cool the jar with water and dry it before a second demonstration or could use a second jar.

Be sure that students understand how this demonstration works. Do not allow science demonstrations to become a magic show.

Family Involvement

Only do at home with parents watching!

Christian Application

Make sure you give God the glory when doing "neat" science activities at home. God created all the "laws of nature" and continues to sustain his creation. Mankind has just scratched the surface in attempting to figure out all the wonders God has done! We must realize that what we call "the laws of science" are likely not the same as "the laws of nature." Our science changes.

Extension

Ask parents if they ever have trouble getting the lids off pots that have cooled.

References

Liem, Tik L. *Invitations to Science Inquiry.* (2nd ed.) Lexington, MA: Ginn, 1981, page 29.

KL

"*Mankind has just scratched the surface in attempting to figure out all the wonders God has done!*"

8. Wonderful Water Skin: A Unique Property of Water—Surface Tension

Equipment Needed

Eye droppers (at least one for each group), waxed paper or heavy plastic sheets, one roll of pennies for each group, liquid detergent, peppercorn, ground pepper, shallow tray, index cards, boat pattern, beaker or transparent container, two clear drinking glasses, toothpicks, paper towels, scissors

Purpose

To show water's tendency to "stick to itself" and how this tendency can be disrupted

Safety—Special Considerations

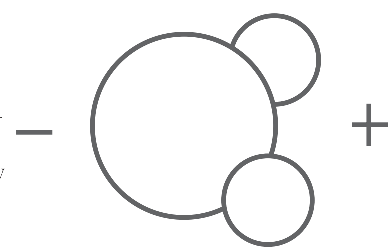
Warn students to be careful while working with glass. All glassware must be free of detergent at the beginning of the activities or the natural surface tension may be lost as soon as water is added. A little detergent can have large effects.

Grade Level—Time Needed

All grade levels with some modifications. The time required is at least 45 minutes, but the activities may be extended over several class periods. Students may benefit by repeating some of them after discussion.

Background

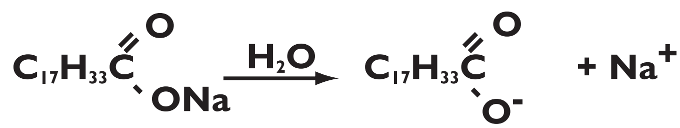
Surface tension is a force that is produced by like molecules attracting each other. Water molecules are polar. They have equal numbers of protons and electrons, but the electrons (-) on the outside are not evenly distributed. Therefore the end of the water molecule with the hydrogens has exposed protons (+). This makes one end of the molecule positive and the other negative. The negative end of a water molecule has a very strong attraction for the positive end of another water molecule. So within a body of water the molecules will be attracted to each other in all directions. The forces are balanced, and the molecules will not move. At the water's surface, however, the story is different. Here the molecules will be mainly attracted to those below and to those on the sides. This pulls the surface molecules tightly downward and creates a thicker film or skin. Because water is so common and fundamental to life, it is important to understand the effects of this force in it. Without this extra polar attraction of water to itself, we would predict that all the water on the planet would be in the gaseous phase. If so, life would be completely different.



The polarity of water can be demonstrated in many ways. One way is to allow a small stream of water to flow from a faucet. Approach the stream with a rubber rod that has been statically charged. The water will be attracted to the rod. A hair comb can be substituted for the rubber rod.

In the course of the lesson it may be necessary to review why things sink. A quick honest answer is that if an item is more dense than the fluid (air, water) it is in, it will sink in that medium. The surface tension of water, however, may be able to support things that are more dense than water.

Students may wonder about the nature of detergents. A detergent is a large molecule that ionizes in water. The length of the detergent ion allows the end that is charged to mix well with water (hydrophilic) while the other end is non-polar (hydrophobic). The non-polar end is not attracted to water. The charged end allows detergent molecules to get in between water molecules while the non-polar-end then disrupts their attraction for each other.



Procedure

Activity One: Penny Overflow

This activity may be done as a demonstration or as a small group activity.

- Take two glasses. Without the students noticing, put a drop of liquid detergent in one glass
- Place the second clear glass on the table. Fill it to the brim with water.
- Ask the student, *How many pennies can I place into the glass before it overflows?*
- Start putting the pennies into the glass of water very carefully—edge in first. Have the students count the pennies.
- Now place the other glass on the table. (The one in which the drop of detergent has been placed.) Run a slow stream of water down the side of the glass (to avoid foaming) to fill the glass to the brim. Be sure to use the same quantity of water as the first glass.
- Ask a student to put the same number of pennies in the second glass.
- Have the students count these pennies as they are being added. Due to the disruption of the surface tension by the detergent, a smaller number of pennies should cause the glass to overflow.
- Discussion of this phenomenon will take place following the completion of the other activities. Students should realize at the end of this activity that there must be a difference between the two containers.

The following activities will solve the mystery.

Activity Two: Stick It to 'Em

- Lay a plastic or waxed paper sheet on a level surface.
- Use an eye dropper to place a single drop of water on the waxed paper or plastic sheet.
- (Demonstrate this step.) Poke a toothpick straight down into a drop of water. Have students do this and observe what happens. (The drop will compress and then reassume its shape when the toothpick is withdrawn.)
- Have the students dip their toothpicks into some liquid detergent and then reinsert them into the water drops as before. Have the students describe what happens. (The drop collapses as the surface tension has been disrupted.)

Activity Three: Let's Get Together

- Place two drops on the plastic/waxed paper about 1/4 inch apart.
- Use a toothpick to nudge one drop toward the other. Watch carefully! Describe the result as the drops converge. (This demonstrates the attraction of water molecules to each other.)

Activity Four: Spice It Down

- Students should fill a clear container with water.
- Have them drop a peppercorn into the water. Observe what happens.
- Shake some ground pepper on the water surface. Compare what happens.
- Place a drop of detergent into the water. Observe what happens to the pepper. (The ground pepper will sink because the detergent has weakened the surface tension.)

Activity Five: Soap on a Boat

- Have the students fill a shallow tray with water.
- Cut a boat from the paper index card. Use the pattern provided.
- Let the paper boat float on the water.
- Place a drop of liquid detergent in the center opening of the boat. Observe what happens. (The boat moves forward as the surface tension is disrupted behind it. Lack of surface tension allows the water to rise.)

The following questions may lead activity related discussion: Ask the questions in the following sequence.

Activity Four:

- *Why did the ground pepper float on the water while the peppercorn sank?*
- *What did the detergent do to the surface of the water?*

Activity Five:

- *Why does the paper boat move forward when the detergent is placed in the hole of the boat?*
- *How did the detergent affect the surface tension of the water?*

Activity One:

- *How many pennies were added to the first glass? How many were added to the second glass?*
- *Considering the outcomes of all the activities, what might have caused water in the second glass to have overflowed more quickly?*
- *How would the number of coins compare if we used dimes instead of pennies or nickels instead of pennies?*

Assignment

Ask the students to summarize their understanding of the nature of surface tension and how this "water skin" can be disrupted. Drawings could be included. If the teacher would prefer, this could be done as a class activity using an experience chart.

Family Involvement

Students may demonstrate what they have learned about surface tension by performing these activities at home.

Christian Application

Water is a special gift of God that possesses many special properties which makes it a unique part of the Creation. One of these special properties is surface tension. Surface tension explains how water moves through soil, into plant roots, and up their stems. Even the movement of blood through the circulatory system depends on surface tension. The surface tension of quiet bodies of water provides a tight film that is strong enough to support organisms (like the common water strider) that inhabit the upper surface of water. Gas exchange in the air sacks of the lungs is dependent upon a thin film of water in the lungs. Here God has provided some special cells (Type II Cells) in the lungs that produce a detergent called surfactant to lower the surface tension. This keeps the tissues of the lungs from being pulled back too tightly when we exhale. Without surfactant every breath would be as difficult as our very first breath was, when we first opened up all the spaces in our lungs which was about fifteen to twenty times as difficult as normal breathing. Sometimes newborns have to be spanked to make them breathe and inflate their lungs.

Water and its special qualities are absolutely essential to earthly life. Jesus used water to teach us about God's Word. The living water of God's Word is essential to the spiritual life of all believers.

Extension

Contrast the surface tension between hot and cold water and between salt water and fresh water. Test different detergents for effectiveness in propelling the boat. Experiment with various shapes of boats or without a hole or with the hole in other locations. Competitive boat races may be held.

The action of a natural detergent called bile in our bodies which allows the digestion of fat may be investigated (Boehlke). Bile breaks up large bodies of fat and allows fat and water to mix.

Related Children's Literature

Orally read the chapter "The Alder Fork—A Fishing Idyll" in *A Sand County Almanac* to older students. Leopold was a thoughtful naturalist with concern for the preservation of the environment. Many of his experiences took place on a Wisconsin farm. This essay shows how God's creation gives us rest, pleasure and occasion to reflect.

References

Boehlke, Paul R. "Bile: A Demonstration." Presentation at The National Anatomy and Physiology Workshop held at Triton College, River Grove, Illinois, June 6-10, 1988 (Available from the author at Wisconsin Lutheran College, Milwaukee, Wisconsin).

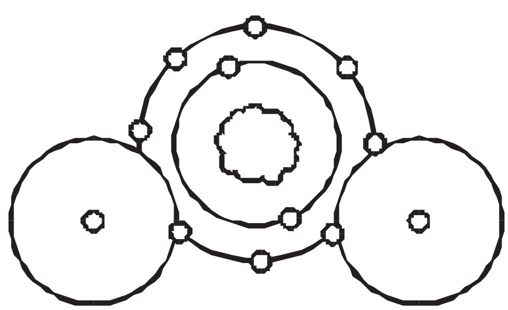
Leopold, Aldo. *A Sand County Almanac*. New York: Oxford University Press, 1966.

Liem, Tik L. *Invitations to Science Inquiry*. Lexington, Massachusetts: Ginn Press, 1981.

Sherwood, Lauralee. *Fundamentals of Physiology: A Human Perspective*. Minneapolis/St. Paul, Minnesota: West, 1995.

Siepak, Karen Lee. *Water*. Greensboro, North Carolina: Carson Dellosa, 1994.

RA and CJ



Wonderful Water Skin

Activity One: Penny Overflow

How many pennies fit in Glass A? ____________

How many pennies fit in Glass B? ____________

Activity: Two Stick it to 'Em

1. Lay a clean detergent free plastic sheet on a level surface.
2. Use an eye dropper and place a single drop of water one the plastic sheet.
3. Poke a toothpick straight down into a drop of water. Observe what happens.
4. Dip the toothpick into liquid detergent and poke the drop again. Describe what happens.

Observations:

Activity Three: Let's Get Together

l. Place two drops on the plastic waxed paper about 1/4 inch apart.

2. Use a toothpick to nudge one drop toward the other. Watch carefully!

Describe the result.

Activity Four: Spice It Down

l. Fill a clear container two-thirds full of water.

2. Drop a peppercorn into the water. Observe what happens.

3. Shake some ground pepper on the water surface. Compare what happens.

4. Place a drop of detergent into the water. Observe what happens to the pepper.

Observations:

Activity Five: Soap on a Boat

1. Fill a shallow pan half full of water.
2. Float a paper boat into the water at one end of the pan.
3. Place a drop of liquid detergent in the center opening of the boat. Tell what happened.

Observations:

Summarize what you have learned about the surface tension of water.

9. Floating Soap Bubbles

Equipment Needed

(For four groups) soap bubble solution, a wand for blowing soap bubbles, four 10 gallon aquariums, 0.5 cup of baking soda (sodium bicarbonate), one cup of vinegar, and four shallow glass dishes that will fit inside the aquariums

Purpose

To demonstrate the unique nature of the soap bubble

Safety—Special Considerations

No special considerations

Grade Level—Time Needed

Upper grades or high school physical science classes, physics classes studying wave interference; Time: one class period

Background

Nearly everyone has enjoyed playing with soap bubbles. A bubble is a thin skin of liquid surrounding a gas. The thin skin is composed of a soap film that has elastic qualities that allow it to stretch. A soap film is composed of molecules of soap and water. Generally, the surface tension of water alone is too strong and the rate of evaporation is too great to allow pure water bubbles to last very long. The addition of soap decreases the surface tension of water by at least one third and adding glycerine slows the rate of evaporation. Making a good soap bubble solution can be challenging because of these variables.

The colors of a bubble are produced by the reflections of light. The small distance between the inside and outside produces an interesting effect. When light bounces off a bubble, some is reflected from the outer surface of the bubble wall, and some passes through to be reflected by the inner surface. The result is that light coming back from a bubble has two reflective surfaces, each with difference distances to travel back to the eye. One has a longer distance to travel (the path difference) than the other. When they return to the eye, the two light waves will interfere with each other. They may reinforce or diminish each other depending on how they match up. When the thickness of the bubble is such that the two reflected waves leave crest to crest (in phase), that color appears brighter (constructive interference). When reflected waves leave the bubble crest to trough (out of phase), the color will cancel due to destructive interference. As the bubble wall gets thinner, the length traveled by the internal light reflection changes, and the colors that interfere constructively and destructively will also change. A bubble will appear white with growing black spots just before it pops. The white color is due to the fact that the bubble's thickness is less than a quarter wavelength thick. For any color of visible light, none of the wavelengths are canceled completely, and therefore the bubble appears white. Black spots appear when all colors are canceled.

If soap bubbles remain floating in the carbon dioxide for more than a minute, the bubbles will slowly become larger. The bubbles will also slowly sink in the layer of carbon dioxide. Both the growth and sinking of the bubbles result from the same process. See if the students can figure this out. When the bubble was blown, it was filled with air. When it settled into the container of carbon dioxide, the bubble was surrounded by this gas. The bubble grows because carbon dioxide moves (diffuses) into the bubble, through the soap film, faster than air moves out of the bubble. Water is the main component of the bubble-soap solution. Carbon dioxide can move through the soap film more quickly than air because it is more soluble in water than air. As the amount of carbon dioxide in the bubble increases, the bubble becomes heavier and sinks lower into the carbon dioxide in which it is floating.

Procedure

Place four aquariums at different draft-free locations around the room. Place the glass dish on the bottom inside of each aquarium. Put 0.5 cup of baking soda in the glass dish. Pour one cup of vinegar into the dish with the backing soda. The mixture of soda and vinegar will immediately start to fizz as the reaction forms carbon dioxide gas. Carbon dioxide is more dense than air and so it will be held in the aquarium as long as it is not agitated by drafts of air over the container. Because carbon dioxide is colorless, you will not be able to see it inside the aquarium.

After the fizzing in the dish has subsided (about a minute), gently blow several soap bubbles over the opening of the aquarium, so that the bubbles settle into the container. This may take a bit of practice. (Do not blow directly into the container, you will blow the carbon dioxide out of it.) While the bubble is floating on the carbon dioxide in the aquarium, observe some of its unique properties. Note its color, any color changes, its size, and whether or not it changes in size, and whether or not its position in the carbon dioxide gas changes with time. Encourage the students to carefully observe. Have them record their observations.

When observation of the bubbles is finished, dispose of the mixture in the glass dish by rinsing it down the drain.

Assignment

The student will summarize the characteristics of soap bubbles in a poem or in the form of a short story.

Family Involvement

The activity could easily be carried out at home and shared with family members.

Christian Application

The creation is wonderful. Visible or invisible, it was all designed and made by God. When we see his works, we have no excuse for not believing (Ro 1:20).

Extension

Students could test different brands of detergents to determine which one would produce the largest bubbles. They could also add varying amounts of glycerine to test for bubble longevity and size. Students could attempt to predict the progression of color changes that signal the eventual bursting of the bubble.

References

Hewitt, Paul G. "Light Waves." *Conceptual Physics*. Glenview, Illinois: Scott, Foresman and Company, 1989, 518-26.

RA

10. Electrical Balloon

Equipment Needed

Puffed wheat, balloon, wool or child's hair, glue (for assignment)

Purpose

To learn that static electricity can be produced by rubbing two objects together

Safety—Special Considerations

Strange as it may seem at first thought, young children need to be warned not to accidentally inhale a balloon into their airway. If a balloon blocks the airway, it is extremely difficult to remove because of its flexibility. Also announce before class that the cereal should not be be eaten. This experiment should be performed on a day with low humidity. High humidity will allow charge to leak into the air.

Grade Level—Time Needed

Primary grades; Time: one class period

Background

Matter is made out of charged particles. Current electricity occurs when charge moves. Static electricity, on the other hand, is caused by the separation of charges which causes either positive or negative charge to be present in unbalanced amounts. This electricity is the type that gives you a shock when you walk on a carpet and then you touch something. Static electricity can be produced by rubbing certain objects together. Balloons become negatively charged when rubbed on wool. A charged object can attract an object that is not charged by causing its charges to move. To illustrate, when a negative balloon comes close to a neutral object the negative charges in it move as far away as they can within the neutral object. This process makes one side of the neutral object positive and the other side negative. Very careful observers will notice that after being attracted at first, a piece of puffed wheat may suddenly be repelled from the balloon. Most students miss this. When the cereal is in contact with the balloon, it can pick up the same charge as the balloon.

Lightning is caused by the discharge of static electricity. It builds up because of the movement of the uplifting air. Children should be taught that God in his goodness uses the energy in lightning to make nitrogen compounds out of the nitrogen in the air. These nitrogen compounds fertilize plants.

There are many technological applications of current electricity invented by humans, but few, if any, involve static charge. Static charge is difficult to control. In fact, it can cause explosions and problems with computers.

Procedure

Before class, blow up a balloon and crumble a few kernels of puffed wheat per child. Have the children try to pick up the puffed wheat with the balloon. Then have them rub the balloon on their hair or a piece of wool and try to pick up the puffed wheat with the balloon. Observe what happens carefully.

Assignment

The children will complete the worksheet, gluing the puffed wheat to show its location during the experiment.

Family Involvement

Children can take the balloon home and check what other objects are attracted to the balloon.

Christian Application

Even though we can't always see electricity we know it is there. Electricity is another part of God's wonderful creation. It has many uses. Electricity can help us enjoy God's creation. For example, with the help of electricity we can watch chicks hatch in an incubator.

Extension

Try this experiment putting the cereal inside the balloon. Another activity is to put the charged balloon by a stream of water. What happens?

You can also try this experiment with pieces of string. Before you begin this activity you may want to read the book *Let's Find Out What Electricity Does* by Martha and Charles Shapp.

References

Shapp, Charles and Martha. *Let's Find Out What Electricity Does*. New York: Franklin Watts, 1975.

Sneider, Cary I., Alan Gould and Budd Wentz. *The Magic of Electricity*. Berkeley, California: University of California, LHS GEMS, 1985.

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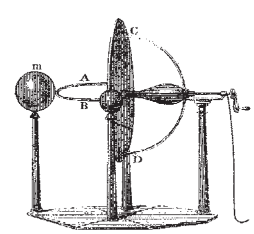
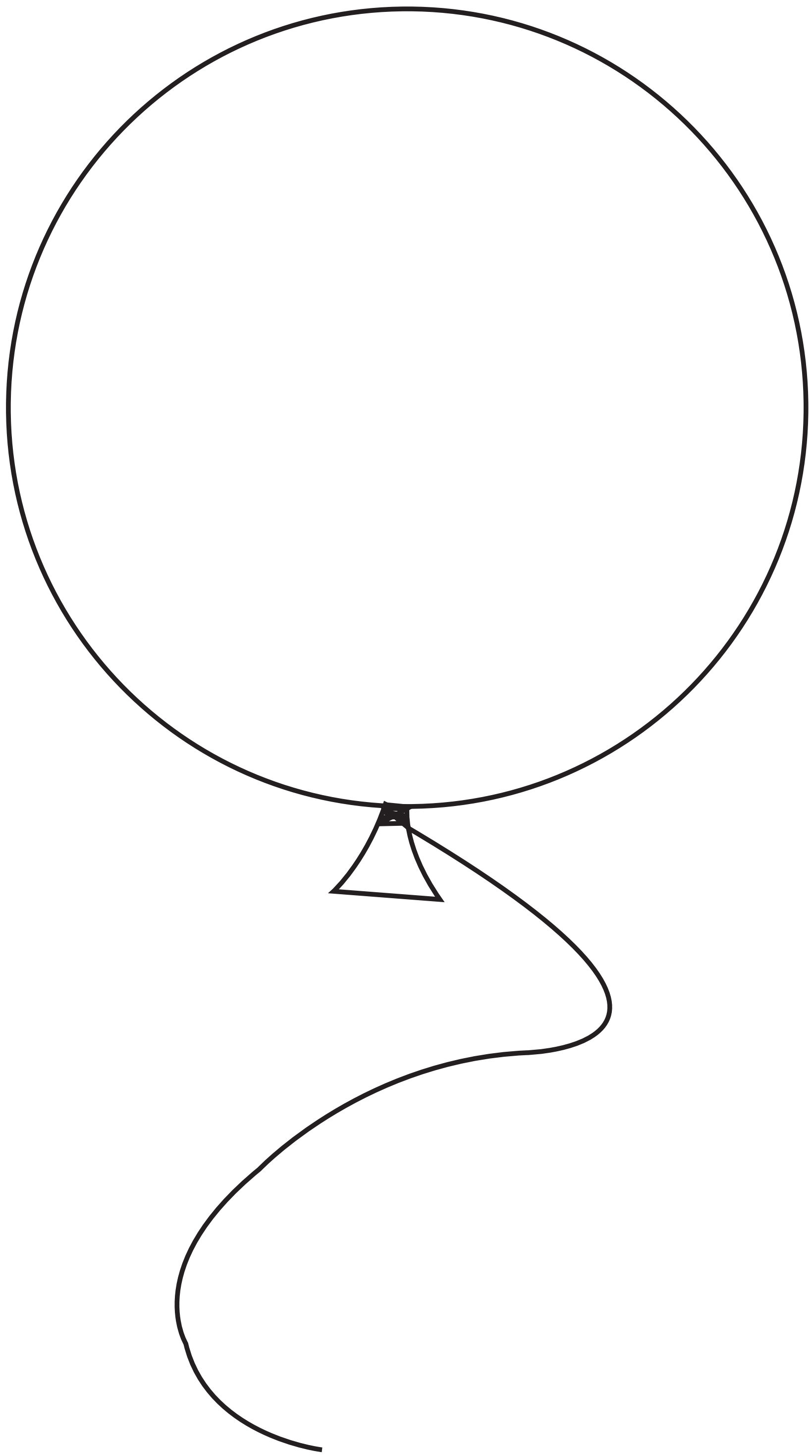


Paste the cereal where you saw it at the end of the experiment.



11. Juicy Jolts

Equipment Needed

Paper clip, piece of copper wire, lemon or lime

Purpose

To feel an electrical shock in a safe way
To learn that a cell is made with two different metals and an electrolyte

Safety—Special Considerations

This is a safe way to feel electricity, but children should be made aware that electricity can be dangerous.

Grade Level—Time Needed

Primary grades; Time: one class period

Background

The electricity is caused by chemistry involving the juice inside and two different metals (copper wire and steel paper clip). Each metal is called an electrode. The juice is a mild acid that serves as an electrolyte. Electrolytes carry electrically charged particles called ions. Ions are atoms that have lost or gained electrons and hence have become charged. When two different metals are placed into an electrolyte, one of the metals will take electrons from the other if a wire is attached between them. If electrons are moving through the wire, oppositely charged ions are moving to the metals in the juice. When the wires are touched to the tongue a closed circuit is created and the electrical flow begins.

Some people check to see if nine volt cells are still good by touching the electrodes to their tongue. If a shock is felt, the cell is good.

The lemon cell is called a wet cell because of the liquid inside. Many cells use a wet paste inside and are called dry cells. The advantage of a dry cell is that it cannot be spilled.

Procedure

Give each student a lemon or lime, a piece of copper wire and a paper clip. Show them how to break the membranes inside by squeezing and rolling the fruit without breaking the outside skin. Then have the students stick a straightened paper clip and the wire into the end of the fruit (the two should not touch). Now the children touch the wire and paper clip (do not touch any metal with your hand) to their tongue at the same time. They should feel a slight tingling. This tells children that an electrical current is flowing through the wire.

Assignment

The children should draw two pictures of electricity used correctly and two pictures of electricity used incorrectly.

Family Involvement

Children could take this experiment home to show their family.

Christian Application

Electricity and God are alike in that we can't see either, but we know they both exist. Electricity is an example of faith. Even though we can't see the electricity we have faith that when we turn on a light switch the light will come on. So is our faith with God. We can't see him but we know that when we turn to him, he will be there.

Extension

Read *Thomas Alva Edison: Young Inventor* by Louis Sabin.

References

Sabin, Louis. *Thomas Alva Edison: Young Inventor*. Mahwah, NJ: Troll Associates, 1983.

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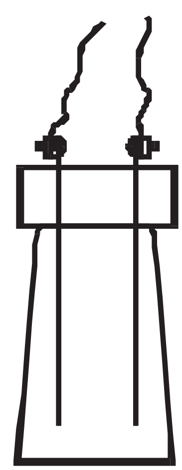

12. Light Bulbs

Equipment Needed

Needed per team: a C or D cell, a flashlight bulb, jumbo paper clip

Purpose

The students will be able to complete an electrical circuit. This activity emphasizes critical thinking to solve a problem with limited materials.

Safety—Special Considerations

Normal lab safety procedures should be followed.

Grade Level—Time Needed

Middle to upper grades; Time: one class period

Background

If a flashlight bulb is placed correctly in a complete circuit so that electricity passes through it, it will light. In order for current to flow through the bulb it must be connected to the circuit at two points, the tip contact (the metal button at the bottom of the bulb) and the base contact (the metal side of the bulbs base). To make the bulb light with the materials above, either the base contact or the tip contact of the bulb must touch one terminal of the cell.

The paper clip must connect the cell's other terminal to the remaining contact.

Procedure

This activity should be done in groups of two. Give each group one cell, bulb and paper clip. Challenge the students: *Can you make the bulb light using only the materials given?* Tell the groups not to tell or show other groups how to solve the problem. Upper grade students should find two ways to light the bulb.

Assignment

The students should draw a diagram of how they lit their bulb. (Older students will draw two pictures).

Christian Application

Science and technology are great blessings. Good stewardship of these blessings requires that we gain as much understanding as possible.

References

Winkleman, Gretchen and Dave Youngs. *Electrical Connections.* Fresno, California: AIMS Education Foundation, 1991.

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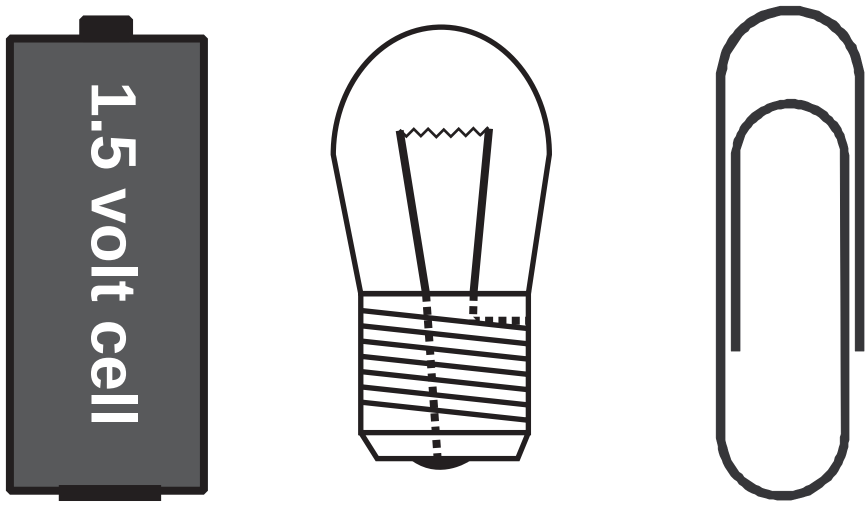
Diagram for Lesson 12



Make a drawing to show how you lit the bulb.

13. What Objects Will Complete the Circuit?

Equipment Needed

One 1.5 volt cell (battery) any size (C or D), a flashlight bulb, three wires with stripped ends, and masking tape for each team of students; some objects to test, such as pencils, pens, pennies, erasers, paper clips, pins, aluminum foil, and marbles

Purpose

The students will classify materials as good conductors or good insulators (non-conductors). They will be able to understand the concept of an electrical circuit.

Safety—Special Considerations

Inform the students that the amount of electricity used in this experiment is harmless, but that they should never experiment with wall current at home. Student should also be taught not to touch bare wires that are connected to household (or unknown) voltages.

Grade Level—Time Needed

Middle and upper grades; Time: one class period

Background

A current is a flow of charged particles (usually electrons, which are negative). The students are working with direct current (DC) in this activity. The electrons in DC electricity flow from the negative electrode to the positive electrode on a cell. In the United States, household electricity is alternating current (AC), and the electrons move back and forth 60 times (60 cycles) each second. In both cases materials that allow electricity to flow easily (on them or through them) are called conductors. The electrons in a good conductor are not tightly bound to the atoms. Therefore the electrons can move easily from one atom to the next. In other materials, the electrons are more tightly attached to the atoms and cannot move freely from one to another. These materials are poor conductors, because electricity cannot flow through them easily. These make good insulators. Every material has a certain amount of resistance, which is the measure of how tightly electrons are bound to their atoms (how difficult it is for electricity to flow through the material). Good conductors have low resistance, while good insulators have high resistance.

Students should be able to generalize from their work (and under the conditions of this activity) that the metals are good conductors while the non-metals are good nonconductors and hence make good insulators. All the chemical elements on the periodic chart are basically divided into metals and nonmetals. Solutions with ions will also conduct electricity while (contrary to common knowledge) pure water does not; pure water is a nonconductor. Specifically, all materials vary in their ability to conduct electricity. One metal can be better than another. The diameter and length of a material can also change the conductivity. Conversely, any insulator can "break down" if the voltage is high enough. For example, rubber tires will not stop lightning because lightning's energy can be as high as 15 million volts. Furthermore, a person's body in this activity is a good insulator (only a small amount of electrons flow and nothing can be felt); but if the voltage is at the household level (115 volts), sufficient current will flow to give a person a shock. Depending on the pathway across the body, this shock could be fatal.

The electricity in this activity is produced by a chemical reaction inside the dry cells. The reaction in a zinc-carbon cell produces about 1.5 volts. Placing cells end to end, in series, increases the voltage. Ignoring internal resistance, two cells in series produce about 3 volts. Three produce

4.5 volts and so on. Cells can also be wired in parallel by attaching the negative ends to each other and then attaching the positive ends to each other. This does not raise the voltage but increases the amounts of chemicals involved and hence the life of the system. Two or more dry cells attached to each other are called a battery. One cell is not a battery although people commonly (and wrongly) will speak that way. One has to be careful, though. A single 6-volt unit looks like a single cell on the outside but inside one will find four 1.5 volt cells in series. Therefore, it is a true battery. A cell will work until its chemicals are used up. One problem with dry cells is that the center electrode which is inside can become covered with hydrogen bubbles this will also stop the chemistry. A person can shake a cell (a flashlight), knock some of the inside bubbles off and see current flow until the bubbles build up again.

Light bulbs light up because the wire (filament) in them heats up as the electrons move through them. Oxygen is removed from the bulb and replaced with an inert gas (usually argon) to prevent the hot filament from being oxidized (burned up). Breaking a bulb lets oxygen in and the filament will not last long. Thomas Edison's biggest challenge in inventing the light bulb was to find a filament that would glow but not melt.

When buying flashlight bulbs for this activity one should look for the amount of voltage they can handle. A bulb may be labeled as a three-battery lamp. This means that it can handle that many cells or 4.5 volts at maximum. However, it will also give a dim light with fewer cells. If students wish to work with more than one cell in series, they can line them up in an open book to prevent them from rolling off the table.

Procedure

- Have the students inspect the materials. Tell the students that a flashlight battery is actually called a cell. A drawing on the board or overhead showing the circuit is a good idea. Have the students examine the light bulb. Tell them that every light bulb has two separate electrical contact areas as parts of its base. Tell them to find these two contact areas which allow electricity to enter and leave. (The teacher could allow students to inspect larger light bulbs for the two metal contacts.) The metal contacts are separated by an insulating material. It is most likely a black plastic. It is typical to use the sides of the base as one contact and the bottom point as the other.
- Construct the circuit. Firmly tape a bare end of wire to each of the contact places on the bulb. Next tape the other end of one of these two wires to one end of the cell. Then tape one end of the third wire (the wire that has not been used yet) to the other end of the battery (see illustration). Place a paper clip so that it is touching the remaining free ends of the wires. If the bulb lights, the paper clip has completed the circuit. The clip is allowing the flow of charge.
- If the bulb does not light, have the students brainstorm to determine what is wrong. (The bulb could be burned out. A wire may not be making contact. The cell may have used up all its chemicals.) The bulb should light because the paper clip is a conductor.
- Explain that conductors allow charge to flow; nonconductors (insulators) do not. Continue this procedure with the rest of the objects. Have the students make a two column list with headings that records which objects are conductors and which are nonconductors. Put the objects into two groups.
- Encourage the students to think about the general properties of conductors and nonconductors. What properties are shared by each group? Can the students make a generalization?

Assignment

Students should complete their worksheets and then write a general statement about the type of materials that conduct electricity and those that do not. These statements can be shared and possibly modified in the next class.

Family Involvement

Students could try this same experiment at home. With parents' permission the parts could be taken from a flashlight (and later returned).

Christian Application

Electricity can be very useful for doing work. On the other hand, electricity can also be very dangerous. We also need to understand that the use of electricity can cause pollution (resources that are out of place). God's command to subdue the earth requires that we understand electricity and use it carefully. We need to think about everything we do.

Extension

- Students could examine flashlights and make a diagram of how the electricity flows in them. Be sure to include an examination of how the switch works.
- What happens if you put a cell in a flashlight backwards? Cells are built so that this does not happen. Nevertheless, students could build and compare circuits which have cells in correct order or backwards. A penny can be placed between two positive ends in order to make the electrical contact. (Three cells in order produces 4.5 volts, turning one produces a net of only 1.5 volts because the backwards cell is trying to send electrons in the other direction. The brightness of the bulb would indicate the net voltage. In any case all the cells are working. Be sure to use a bulb that is built to work at the voltage that is produced or the filament will melt.
- Devito and Krockover have a nice activity that shows how a light dimmer works. In the place of the material being tested, they place a long coil made by turning thin, good conducting wire around a pencil. They then attach one wire of the circuit to the end of the coil and vary where the student touches the other wire to the coil. More coil in the circuit increases the resistance, and the light is dimmer. Less coil allows more electricity to flow, and the light is brighter.

References

Devito, Alfred and Gerald H. Krockover. *Creative Sciencing: Ideas and Activities for Teachers and Children.* Boston: Little, Brown, 1980, pages 123-124.

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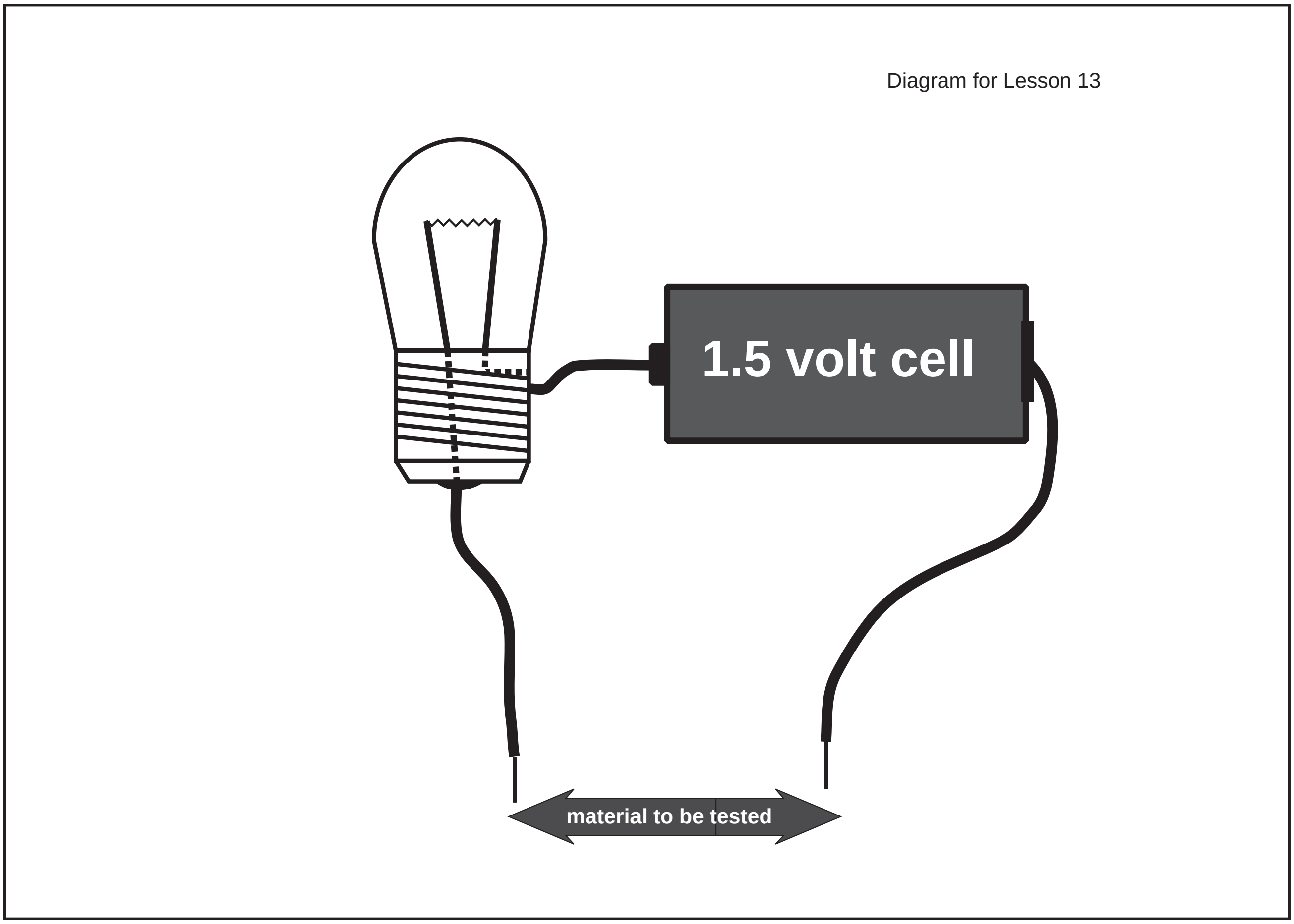
> *...metals are good conductors while the non-metals are good nonconductors and hence make good insulators.*



Data chart for Lesson 13

What Objects Will Complete the Circuit?

Object	Did the light go on?	Was it a good conductor?	Was it a good insulator?
Pencil			
Pen			
Penny			
Eraser			
Paper clip			
Pin			
Aluminum foil			
Marbles			

14. Circuit Quiz Boards

Equipment Needed

Per group: a file folder, C or D cell, miniature Christmas lights which have been separated from each other, 10 strips of aluminum foil 1 cm x 30 cm, roll of masking tape, two 30-35 cm pieces of wire with ends stripped, hole punch, scissors, rubber band, glue

Purpose

The student will be able to complete parallel circuits.

Safety—Special Considerations

Remind student that the low voltages make this activity safe. Students should be reminded not to experiment with household currents.

Grade Level—Time Needed

Middle to upper grades; the total time will vary. Allow students to work on this project at their own pace.

Background

The quiz board works like an old-fashioned phone switchboard. Each question is connected to the correct answer by a strip of aluminum foil. The foil is covered by masking tape to insulate and prevent short circuits. When a question and its correct answer are chosen, it completes the circuit, causing the bulb to light.

Procedure

The students should work in small groups (2-4 students) for this activity. Each group should write 10 questions with brief matching answers. (Why not correlate this activity with another subject area that is being taught at this time?) Give each group a copy of the blank questions and answer sheet. Each group writes its questions in the left column and then writes the answers randomly arranged in the right column. Using the file folders, the students glue the question and answer sheet to the file folder front. Use a hole punch to make a hole to each question and each answer. Then inside the folder, draw lines from the hole for each question to the hole for the matching answer. Distribute aluminum foil strips, scissors, and tape. Place a foil strip over each line (this is the line the student just drew) so that the foil extends beyond the hole, trimming if necessary. Tape the foil ends to cover the holes, then place tape on top of the foil (make sure no foil is showing). Repeat this process until all strips are covered and taped. Remember that no foil should be showing.

Distribute a cell, bulb and two wires to each group. Tape a long wire to the negative (flat) end of the cell. Attach one of the wires from the light bulb to the positive end of the cell. To help maintain good contacts, wind a rubber band lengthwise around the cell over the wires. Carefully tape the cell onto the question and answer sheet. Attach the second long wire to the other wire coming from the bulb by twisting it and then taping. Anchor the bulb with tape. Have students test their quiz boards by touching the wire from the bulb to the foil (which is showing through the hole) beside the first question, at the same time touching the wire from the battery to the foil beside the corresponding answer. The bulb should light. The connections can be tested by touching the two wires together without using the quiz board.

Assignment

Students should exchange their boards with other students.

Christian Application

This activity is another example of how wise God is. He is all-knowing and can do anything. Electricity, which is part of the creation, can be used for many things. Nevertheless, we must exercise care for the environment. The use of electricity can cause pollution. We must take care to minimize damage to the creation. Everything we do can affect our environment.

Extension

Design a circuit quiz board that uses a buzzer instead of a light.

References

Winkleman, Gretchen and Dave Youngs. *Electrical Connections*. Fresno, California: AIMS Education Foundation, 1991.

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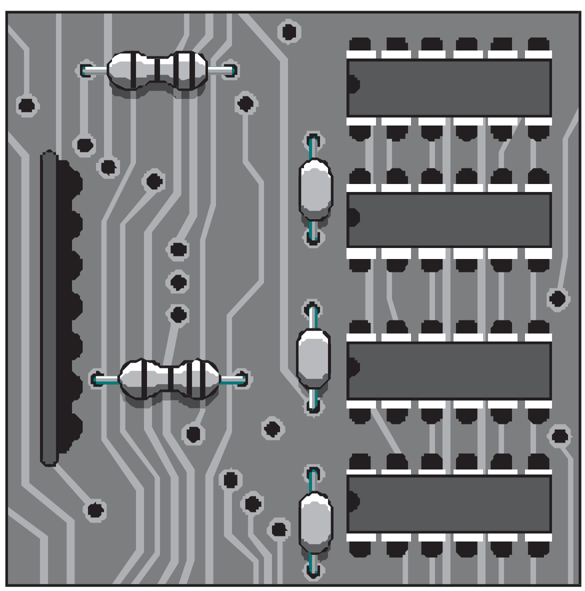


	Questions	Answers
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

15. Horsepower

Equipment Needed

A bathroom scale, stopwatch, flight of stairs, calculator (optional)

Purpose

To calculate the horsepower developed by running up a flight of stairs

Safety—Special Considerations

Caution the students to go quickly but safely. No running starts. Make sure that the stairway is clear.

Grade Level—Time Needed

Grades five and up; Time: one class period

Background

This activity requires little equipment and generates high interest. It makes a great culminating activity to a unit on machines or force. Since work is defined as force times distance, time will not affect how much work is done. Power, on the other hand, is the rate at which work is done. Two students may weigh the same, but they will generate different amounts of power if they have different times. An example of one horsepower is lifting 550 pounds a distance of one foot in one second.

Procedure

Students are timed as they go quickly up a flight of stairs. You need three measurements to calculate horsepower: (1) the height of the stairs in feet, (2) the student's weight in pounds, and (3) the number of seconds required to run up the stairs. (See Chart 1.) The timer should stand at the top of the stairs and shout, "Go." Students may want to try two or three times and use their best time. The formula for determining horsepower is

$$\text{Horsepower} = \frac{\text{weight} \times \text{stair height}}{550 \times \text{time}}$$

Assignment

Describe how to perform this activity so you can conduct it at home.

Family Involvement

This activity could be tried at home with siblings and parents.

Christian Application

This experiment shows that we all have muscles which give us power to do work. Whether we are are large or small we can work for the Lord. As we look at the world around us, at the mountains that God has lifted up or at the stars in the sky, we can see just a tiny part of the awesome power of God.

Extension

How is the formula developed? What is the difference between the power that may change from trial to trial and the work which remains constant? Consider whether a style of staircase such as spiral or straight requires less power to use than another; less work? (Our calculations are not sensitive to actual work done in directions other than vertical. Different styles of staircases will no doubt result in different results because of this. This is actually because of different difficulties in changing direction, distances, and forces used in completing the vertical distance.)

References

Tolman, Marvin N. and James O. Morton. *Physical Science Activities for Grades 2-8*. Science Curriculum Activities Library, West Nyack, New York: Parker Publishing, 1986, p 64.

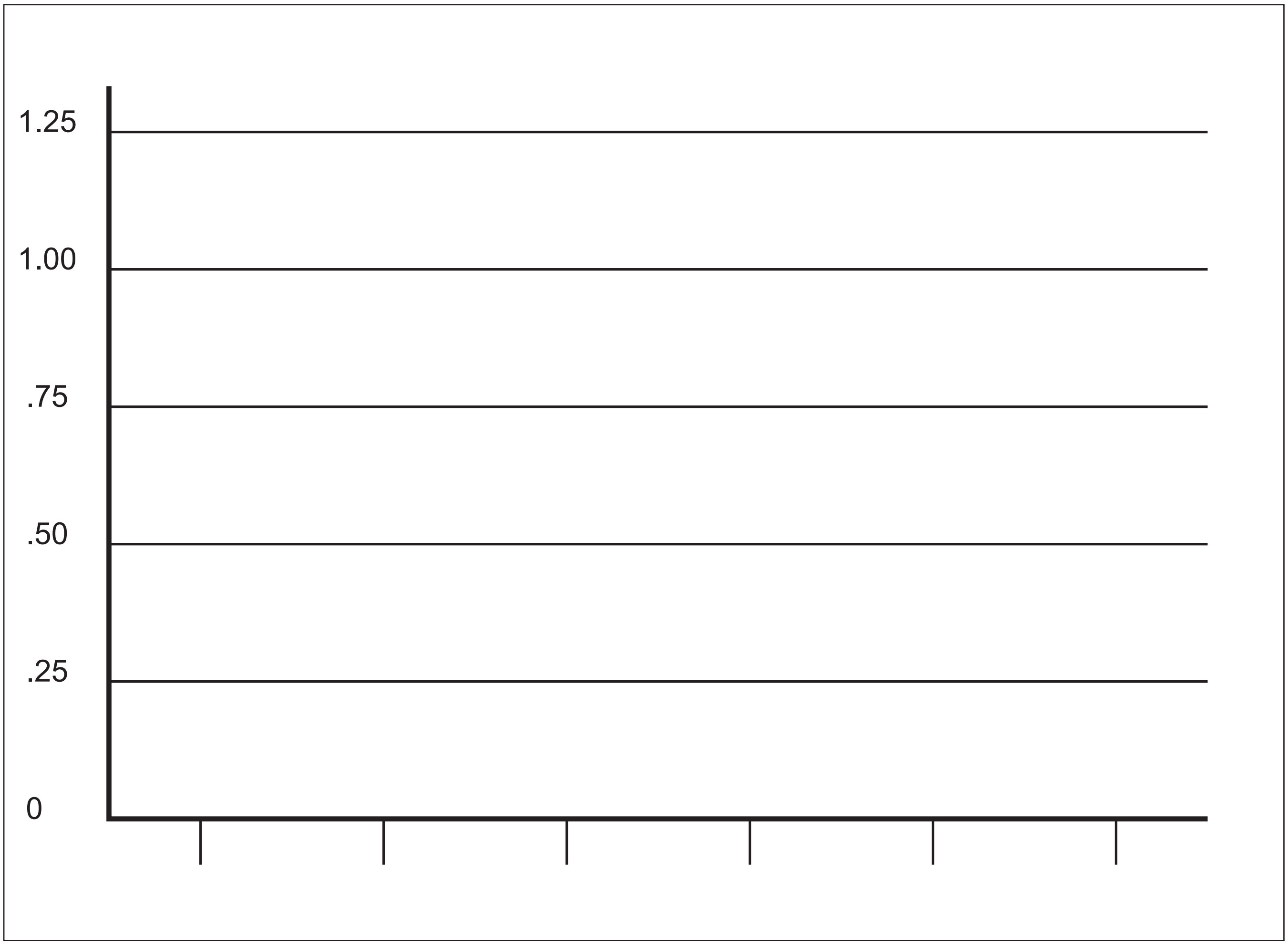
PT

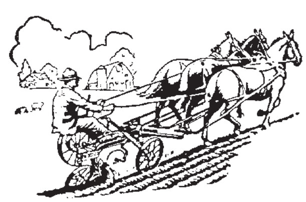
Chart 1
Measuring Horsepower

(a) height of one stair	ft
(b) total number of steps to climb	
(c) total height of steps [a x b]	ft
(d) weight	lbs
(e) work done in climbing stairs [c x d]	
(f) time needed in climbing steps	sec
(g) power used in climbing steps [e/f]	hp

Optional Bar Graph

Complete the bar graph below by adding labels and the data from your group.





16. Levers

Equipment Needed

Meter stick, triangular shape (fulcrum), 25 pennies (one set for each group)

Purpose

To build a first class lever and to explore effort and distance

Safety—Special Considerations

Be careful when you try to lift large objects. The lever and fulcrum must be strong enough for the task or they may break and injure you or someone nearby. It is best an adult is present when students try to lift large objects because injuries to people or damage to property may occur if the lifting is not done carefully.

Grade Level—Time Needed

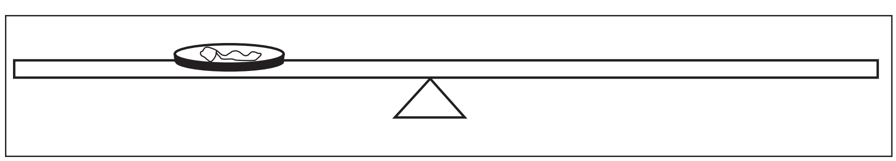
Grades 5-8; Time: one class period

Background

Archimedes (c. 287-212 B.C.), an ancient inventor and mathematician, pioneered the study of mechanics including levers. He showed that heavy objects could be lifted with little effort by moving the pivot (fulcrum) close to the object to be moved. He also showed that the effort should be applied as far away from the fulcrum as possible. “Give me a place to stand and I will move the earth,” Archimedes boldly stated. His tests also proved that the effort times the distance from the fulcrum equals the load times its distance from the fulcrum. This would be true in an ideal situation that does not count the weight of the lever, air resistance, friction, and other forces.

Procedure

Place the meter stick on the fulcrum so the stick balances. Put one penny on the 40 cm mark and predict where a second penny will need to be placed to regain balance. Next, place two pennies at the 40 cm mark. Predict where one coin would have to be placed to achieve balance. (Remember what Archimedes suggested.) Repeat using loads of 3, 4, 5, 6, 7, and 8 pennies on the 40 cm mark. Use more than one penny on the effort side if necessary. (See Chart 1). If you have time you could repeat the entire procedure using the 30 cm mark as the load point.



Assignment

Complete the Data Sheet

Family Involvement

Balance various family members on a teeter-totter at a park. Place the larger family members closest to the fulcrum. Draw illustrations of your results.

Christian Application

We Christians need balance in our lives. When we do lots of work, we need to balance that with lots of rest. When we have lots of stress in our lives, we need to balance that with some time for prayer and meditation. The prayers may be short but lots of them can balance a large load of stress.

Extension

(1) Start with two pennies at different positions on the load side of the meter stick. (2) Move the fulcrum to different positions while measuring effort. (3) Try lifting an adult person with a strong plank and fulcrum. 4) Could you really move the earth as Archimedes said?

References

Historical Science Experiments on File: Experiments, Demonstrations, & Projects for the School & Home. New York: Facts on File, 1993.
Marson, Ron. *Machines #22.* TOPS Learning Systems Task Card Series, 10970 S. Mulino Rd., Canby OR 97013, 1987.

PT

Chart 1
Balancing Pennies

Number of pennies on load size (on 40 cm mark)	Cm location of penny on effort side (distance from fulcrum)

Try two or three of your findings in the following table to test Archimedes' principle.

Load Side				Effort Side		
(number of pennies)	times	(distance from fulcrum)	equal	(number of pennies)	times	(distance from fulcrum)
______	x	______	=	______	x	______
______	x	______	=	______	x	______
______	x	______	=	______	x	______

What could you conclude from your results?

Draw a diagram of one of your setups in the chart above.

17. Let's Have a Swinging Time with Pendulums

Equipment Needed

Used cereal box about 1/6 full of gravel, Pendulum Plotter (see picture), large washer, paper clip, string, tape, stopwatch (one set for each group)

Purpose

To explore a pendulum's period (the time for a back and forth swing) and amplitude (height of the swing) and their relationship

Safety—Special Considerations

Tape the bottom of the box shut so that no gravel can leak out. Be careful not to drop the box or spill the gravel.

Grade Level—Time Needed

Grades 5-8; Time: one class period

Background

Galileo (1564-1642) made an amazing discovery sitting in church! He noted that the swinging lamp suspended from the ceiling took the same time to complete a back and forth swing, although the distance the lamp traveled decreased over time. Galileo used his own pulse as a timer to test his observation.

Procedure

With the cereal box tipped on its side, tape the Pendulum Plotter to the side so that the upper edge of the plotter is even with the top edge of the cereal box so that about 5-10 mm of the straight wire sticks out. Tie one end of a string to the washer. Tie the other end of the string to the wire of the paper clip so that the pendulum is about 12 cm long. Check to see that the washer can swing from side to side in a straight plane as close as possible to the box without touching it. (See Diagram 1.)

Pull the washer to amplitude marker #1. Time 25 cycles. Count back and forth as one cycle. Repeat the procedure. Pull the washer to amplitude marker #2 and follow the same procedure. (See data tables.) Continue for amplitude markers #3 and #4. You might ask questions such as these:

- *What patterns can you find in your data?*
- *What might the number of cycles be if we pulled the pendulum back to marker #5?*
- *What can you conclude about amplitude and time for 25 cycles of a given pendulum?*
- *If you have time you could shorten or lengthen the string and run the same procedures.*

Assignment

Complete the data chart and summary statement.

Family Involvement

Try this experiment on a swing at home or at a park using different amplitudes and people with different weights. Time 25 cycles of each trial.

Christian Application

During Galileo's life, scientific thought and Christian dogma were inseparable in the Roman Catholic faith. Galileo showed that science is not an absolute. Since science is made from the mind of man, it, unlike the Word of God, can and does change.

Extension

(1) Graph the results. (2) Compare the length of the string to frequency (the number of cycles per minute). (3) Compare the length of the string to the period. (4) Use two or more washers and compare results.

References

Historical Science Experiments on File: Experiments, Demonstrations, & Projects for the School & Home. New York: Facts on File, 1993.

Marson, Ron. *Pendulums #22.* TOPS Learning Systems Task Card Series, 10970 S. Mulino Rd, Canby OR 97013, 1987.

Wiese, Jim. *Roller Coaster Science: 50 Wet, Wacky, Wild, Dizzy Experiments About Things Kids Like Best.* New York: John Wiley, 1994, pages 7-16.

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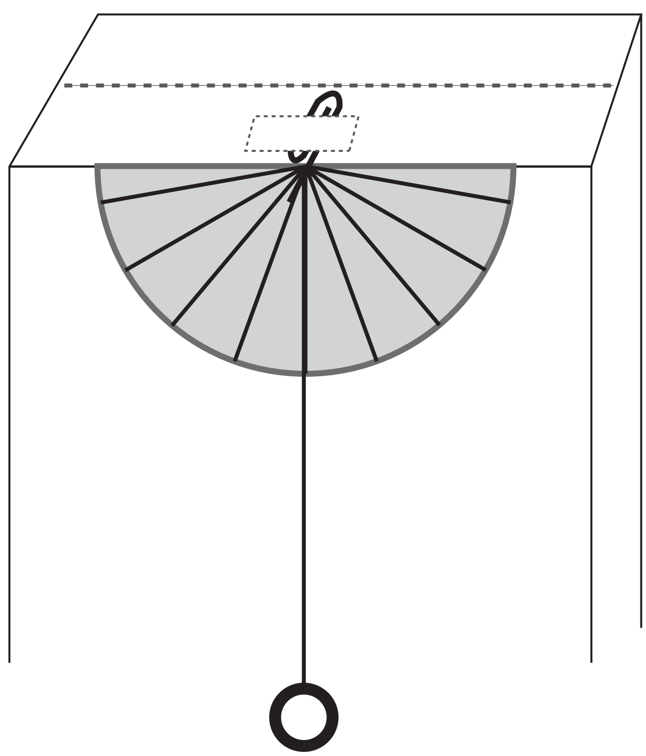
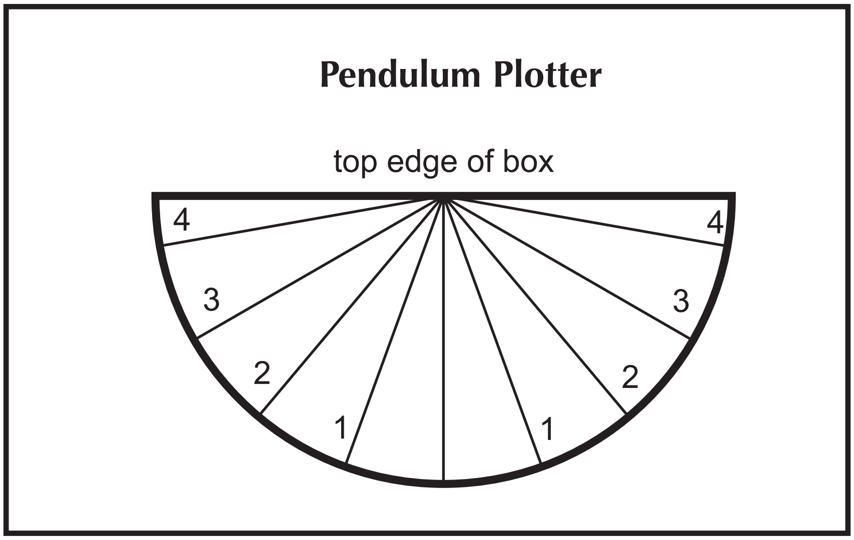
Diagram 1



Cut out this plotter and tape to your box.



Data Tables

Amplitude	time required for 25 cycles

String length	Frequency

String length	Period

Describe what you have discovered about pendulums.

18. Pendulums and Conservation of Energy

Equipment Needed

Large room with a strong hook near the center of the ceiling (a hook in the doorway could also be used), milk jug filled with water, fishing line

Purpose

To understand the concept of conservation of energy by using a large pendulum

Safety—Special Considerations

You will be swinging a pendulum through a relatively large distance. Your room needs to have a clear aisle. Make sure that the hook and fishing line are sufficiently strong to support the milk jug full of water.

Grade Level—Time Needed

Grades K-12; Time: one-half of the class period

Background

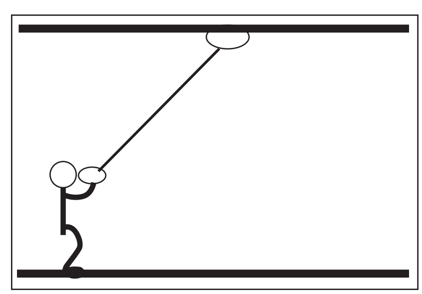
This activity is a quick teacher demonstration that will probably require more time to set up than to do the activity itself. However, the results are well worth the time and effort. Practice several times so you reaffirm your own understanding! The higher the ceiling and thus the longer the pendulum the more effective the show. Each swing of the pendulum will be slightly lower than the previous swing due to loss of energy from air resistance and friction at the hook.

Procedure

Attach the filled milk jug to the fishing line. Suspend the jug from the ceiling hook approximately 50 cm off the floor. Walk the jug to a point so that when the line is taut, the jug is about at eye level. Have students predict if you will need to "duck" on the back swing of the first cycle. Release the jug and allow it to complete a swing.

Assignment

Explain why the second swing is less than the first.



Family Involvement

Try a similar experiment at home or at a park wherever a children's swing can be found.

Christian Application

If we let the jug swing without putting any outside energy into it, the jug will stop swinging. We Christians need outside energy from hearing the Word, attending church services and personal devotions to keep our faith life going. Without the outside work of the Holy Spirit in our lives, our faith lives would also die like a pendulum without outside energy.

Extension

(1) Mark the floor with tape beginning at a point directly below the free hanging jug. Mark off equal intervals in both directions of the swing of the jug. Make predictions about how far the jug will swing depending on initial starting point. (2) What will be required to get the pendulum to swing beyond the starting point? (3) What will happen to the jug if you continue to let it swing? Why ? (4) The students will enjoy developing other extensions. Experiment!

References

Marson, Ron. *Pendulums #34*. TOPS Learning Systems Task Card Series, 10970 S. Mulino Rd, Canby OR 97013, 1987.

Tolman, Marvin N. and James O. Morton. *Physical Science Activities for Grades 2-8*. Science Curriculum Activities Library, West Nyack, New York: Parker Publishing, 1986, page 63.

Wiese, Jim. Roller *Coaster Science: 50 Wet, Wacky, Wild, Dizzy Experiments About Things Kids Like Best.* New York: John Wiley, 1994, pages 7-16.

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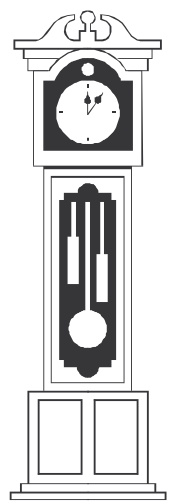


19. Mass and Inertia: Thanks to Galileo

Equipment Needed

Meter stick (two for additional option), three marbles of the same size, three pennies, paper cup, four meters of cord or string, tape, scissors, and data sheet for each group of students

Purpose

To explore inertia through mass and motion

Safety—Special Considerations

None

Grade Level—Time Needed

Grades K-12, difficulty level can be increased by making more accurate measurements, charting results, or building run-up ramp option (below 7th grade this activity is primarily teacher demonstration); Time: one class period

Background

This activity is based on Galileo's (1564-1642) hypothesis that moving objects will keep moving in a straight line forever in the absence of friction or other opposing forces. This was contrary to Aristotle's (384-322 BC) teaching, and therefore opposed what the Roman Catholic Church officially believed. Eventually, Galileo applied his idea of inertia to the Earth claiming that our planet could be in continuous motion around the Sun without a continuous force being applied, and so was charged with heresy in 1633. After being shown the torture chamber, he took back his statement that the Earth moved. Nevertheless, he privately continued to believe that it did. Later Isaac Newton (1642-1727) used Galileo's idea to propose a new vision of the universe: planets moving around the Sun under the force of gravity. He wrote that in *Philosophæ Naturalis Principia Mathematica* (Mathematical Principles of Natural Science) published in 1686.

In this activity gravity is the force acting on the marble as it moves down the meter stick. Once the marble leaves the ramp, gravity can no longer accelerate the marble, but as Galileo explains, the marble continues to move on the table because of inertia. Without friction or the influence of other forces, the marble would continue to move forever. However, we can attempt to measure the inertial force it has gained on the ramp by letting it hit and move a cup. This will need to be explained carefully to the students. Friction, air resistance, and an inelastic collision with the cup will cause some transfer of energy (losses) that we will not be able to measure. Remind students that energy is never destroyed; it always goes somewhere. Finally, the room is going to be ever so slightly warmer because of all the moving cups.

Procedure

- Tape two strings along top edges of meter stick(s) to serve as rails as shown on the student sheet.
- Tape end of one meter stick to table (or floor), allow 3' to 4' between downhill end the stick to end of table. The table should be clear of obstacles and clean to reduce friction.
- Place untaped end of meter stick on stack of three books.
- Cut a doorway in the rim of the paper or plastic cup, not Styrofoam, and set it upside-down on the table at the end of the meter stick. The notch or hole should face the meter stick so that the marble can enter and push the cup.

- Release a marble from a given point on the meter stick and record distance cup is moved from end of the stick.
- Repeat step 5 but add one or two marbles.
- Repeat steps five and six but add one or two pennies (taped on) to top of cup.
- Repeat steps 5-7 but remove a book from the stack.
- Chart results, describe how adding pennies (increasing mass) affects body at rest, describe how adding marbles (increasing force) affects body at rest.
- Run-up ramp option: Instead of cup at end of meter stick install an uphill stick (a paper bridge to eliminate the dip will help) and measure how far up the second meter stick the marble(s) will roll.

Assignment

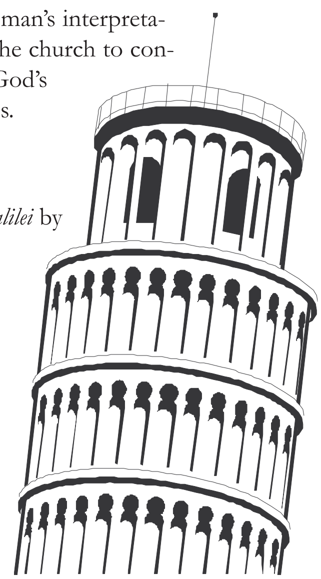
Record measurements and diagram results on student sheet

Family Involvement

Try this at home on a 1) kitchen table, 2) counter top, 3) hardwood or tiled floor, and compare results.

Christian Application

We must keep nature and science separate. Since science is man's interpretation of nature, science changes, and it is not the place for the church to consider a man's scientific opinion to be absolute truth. Only God's Word remains the same. History shows that science changes.



Extension

Have the children read *Truth on Trial: The Story of Galileo Galilei* by Vicki Cobb or *Galileo* by Leonard Everett Fisher.

References

Marson, Ron. *Motion #21. TOPS Learning Systems Task Card Series,* 10970 S. Mulino Rd, Canby OR 97013, 1990.
Cobb, Vicki. *Truth on Trial: The Story of Galileo Galilei.* New York: Coward, McCann & Geoghegan, 1979.
Fisher, Leonard E. *Galileo.* New York: Macmillan, 1992.
Mason, Stehen F. *A History of the Sciences.* New York: Collier Books, 1962.

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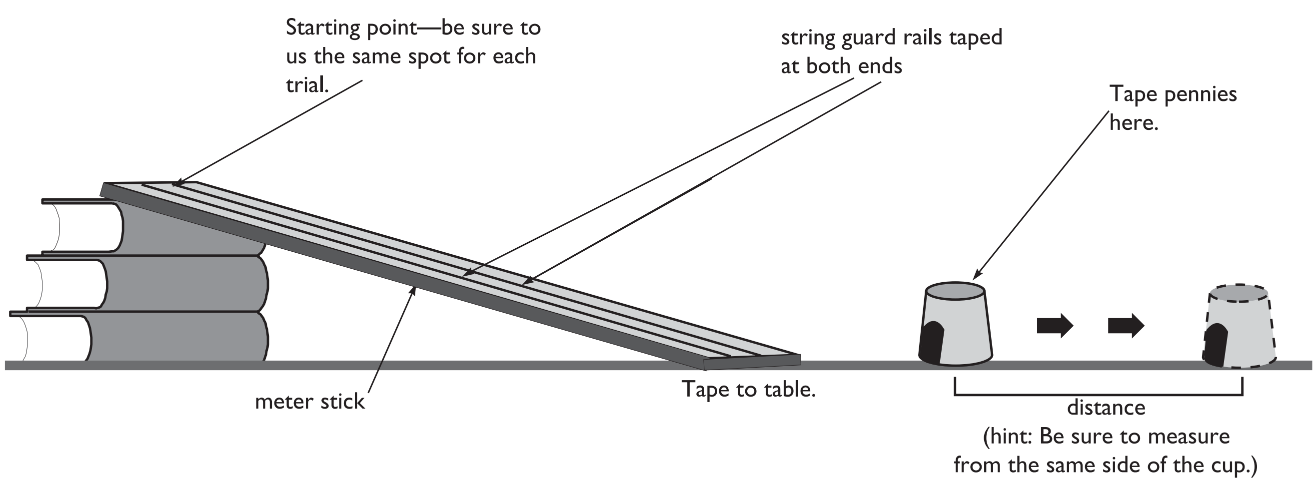
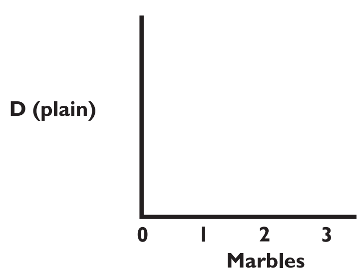
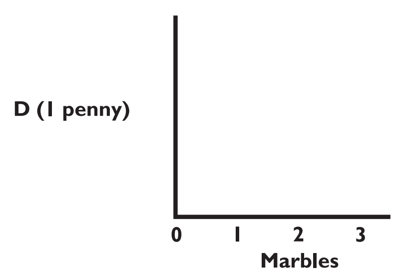
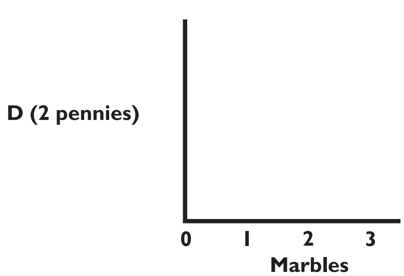


Distance (cm)

Marbles	plain	1 penny	2 pennies	3 pennies
0				
1				
2				
3				







(Hint: Be sure to construct a vertical scale on each graph)

20. Density and Buoyancy

Equipment Needed

There are seven activities in this topic, the equipment is listed by activity number.

A1 large beaker or container, uncooked chicken egg (with shell), table salt, stirring stick
A2 modeling clay, beaker, water, marking pen
A3 granulated sugar, small test tube, balance scale & paper clips or standard balance beam scale
A4 sand, salt, small test tube, balance scale & paper clips or standard balance beam scale
A5 overflow cup, water, beaker or jar, 50 ml graduated cylinder, balance scale & paper clips or balance beam scale, rubber stopper, cork stopper, candle, straight pin
A6 six test tubes per group, corn oil, rubbing alcohol, candle, water, record chart
A7 large jar or graduated cylinder, baby oil, rubbing alcohol, corn oil, water

Purpose

To explore the concepts of density and buoyancy as they relate to solids and liquids

Grade Level—Time Needed

Grade Activities 1-2—K-2 and up
Activities 3-5—3-6 and up
Activities 6-7—7 and up
Time: one class period per activity

Background

Archimedes (287-212 BC) discovered the principle of buoyancy and relative densities. According to tradition Archimedes found that King Hiero's crown displaced more water than an equal weight of gold showing that the crown was not made entirely of gold but also of some less-dense metal. This series of activities demonstrates that different substances have different densities and that substances with lower densities float on top of liquids with higher densities.

Procedure

Activity 1:

- Fill beaker $^2/_3$ full with water.
- Ask students, *Will the egg sink or float?*—immerse egg carefully.
- Add salt and stir (without breaking egg!) until egg starts to float.
- Try same activity but add sugar, baking soda, corn syrup, etc., instead of salt. (See diagram A1.)

1) *What would the density of the raw egg be compared with pure water?* (Greater—sinks)
2) *By adding the salt to the water, what property was increased?* (Density of water)
3) *What two properties are we comparing, when we want to know whether an object will float in a particular liquid or not?* (Density of liquid vs. density of object)
4) *How can we determine the volume of an egg?* (Volume of water displaced—spilled over)
5) *How can we determine the weight density of an egg?* (Divide weight of egg by volume of water displaced)

Activity 2:

- Make a ball of clay with a diameter of approximately five cm.
- Fill beaker $^1/_2$ full and mark level of water.
- Ask students, *Will clay sink or float?*—submerge, mark level of water, and remove ball.
- Flatten ball into boat and let it float on water, compare water level with previous mark. (See diagram A2.)

1) *Was the clay ball heavier than the boat?* (no)
2) *Which of the two displaced more water?* (boat)
3) *What is the volume of the displaced water equal to?* (volume of the submerged part of the boat or total ball)
4) *What is the weight of the displaced water equal to?* (the buoyant or upward force)
5) *Would we be able to float iron or lead this way?* (yes) (Conclusion—For floating objects, the buoyant force is equal to the weight of the floating object.)

Activity 3

- Fill a test tube (of known volume) with sugar, tap it down and level off
- Weigh sugar on balance beam or balance scale with paper clips.
- Divide mass (from scale) by volume of test tube and compute density in grams/ml or paper clips/test tube (pcs/tt).
- Repeat steps 1-3 with 2 test tubes, then with 3 test tubes.
- Compare results.
- Sugar is heavy by the bag but light by the spoonful. *Does its density change?* (No—density is based on mass per unit volume)

(Note—Be sure to subtract out the weight [mass] of the test tube.)

Activity 4

- Repeat A3 using salt and sand in place of sugar.
- Compare the densities of the three substances and arrange in order from least to most dense. (sample possibilities)

Least dense:	sugar (17.2 pcs/tt)
	salt (24.8 pcs/tt)
Most dense:	sand (27.2 pcs/tt)

Activity 5

- Construct an overflow device by making two cuts down the side of a paper or plastic cup and folding the strip down to make an overflow spout.
- Fill cup to overflowing and let excess run off.
- Weigh a cork stopper and when dripping has stopped, forcefully submerge it in the water (pushing it under water with the straight pin so that it is completely submerged) and catching the water that is forced out of the cup in a graduated cylinder.
- Divide weight of stopper by volume of water in cylinder.
- Repeat steps 2-4 first with candle and then with the rubber stopper.
- Arrange in order from least to most dense.
- Candle floats but rubber stopper sinks—*Do your calculations support this conclusion?* (See diagram A5.)

For example:

rubber	= 42.0 pcs/16.0 ml = 2.6 pcs/ml	= 1.3 g/ml
cork	= 10.2 pcs/21.3 ml = 0.48 pcs/ml	= 0.24 g/ml
wax	= 32.8 pcs/18.0 ml = 1.82 pcs/ml	= 0.91 g/ml

Therefore, a candle with density of 0.92 g/ml floats on water with a density of 1.0 g/ml; the rubber stopper with density of 1.3 g/ml will sink in water with density of 1.0 g/ml

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Activity 6

- Add 2 liquids to each test tube, mix gently.
- If one layer forms, write "one layer" in the corresponding square on the record sheet.

- If two layers form, record which liquid is on top and which is on the bottom in the corresponding square.
- Repeat for **five** remaining combinations.
- *How does density determine the floating/sinking action of liquids according to your results?* (See diagram A6.)

Activity 7

- Draw a picture of what you predict a test tube will look like if equal portions of water, corn oil, rubbing alcohol, and baby oil are gently added by pouring down the side of the test tube.
- Add liquids to test tube in given order and check your prediction.
- Draw a picture of what you predict the test tube will look like after you gently mix the liquids.
- Mix and test.
- *What happens if you vigorously mix the liquids?* (Only the appearance changes)
  Before mixing: water on bottom, corn oil above water, rubbing alcohol above corn oil, and baby oil on top
  After gentle mixing: baby oil and corn oil on top, water and rubbing alcohol on the bottom
  After vigorous mixing: they all mix into one layer, but given time the water and rubbing alcohol combination will again settle and the 2 phases will reform (See diagram A7.)

Assignment

Record predictions and observations and then diagram results.

Family Involvement

See if you can get a golf ball to float in a jar of water
Will solid butter or margarine sink or float?

Christian Application

Jesus told his disciples to cast their nets for fish, and they loaded the boat with so many fish that it began to sink. The boat was then demonstrating the principle of buoyancy. When Jesus walked on the water during a storm, he was not bound by the laws of science because he is God. Theories and laws of science are made by man. God did not fit his creation into a set of pre-existing conditions. The conditions came into being during the act of creation. Therefore laws and theories of science are mankind's attempt to interpret the conditions and order in the physical environment.

Extension

Activity 1—Would an egg float in rubbing alcohol? Corn oil? Baby oil? (No)
Activity 4—Try to "compress" sugar and salt. Can they be made more dense?

References

A1 & 2 from: Liem, Tik L., *Invitations to Science Inquiry*. Lexington, MA: Ginn Press, 1985, pages 113-117.

A3—7 from: Marson, Ron. *Floating & Sinking #9. TOPS Learning Systems Task Card Series,* 10970 S. Mulino Rd, Canby OR 97013, 1978.

Tolman, Marvin N. and James O. Morton. *Physical Science Activities for Grades 2-8. Science Curriculum Activities Library,* West Nyack, New York: Parker Publishing, 1986, pages 40-41.

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Diagram A1

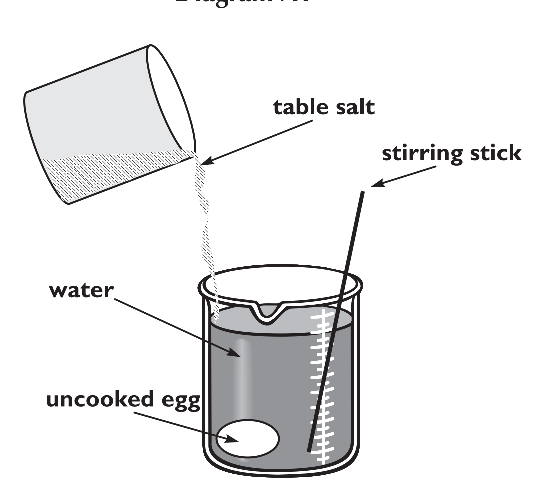


Diagram A5

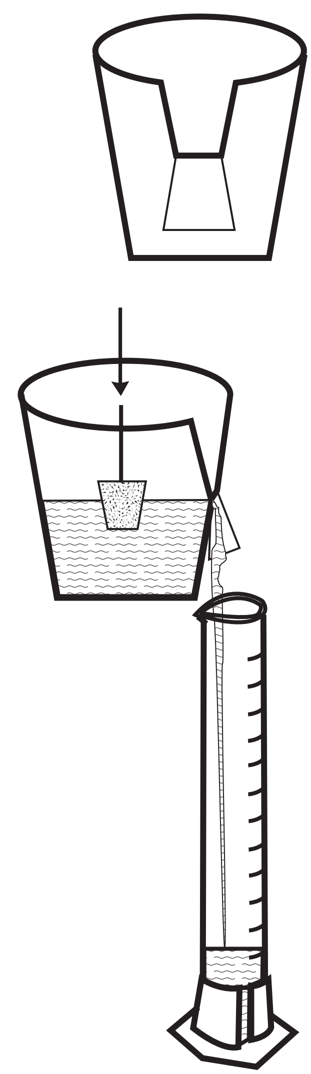


Diagram A2

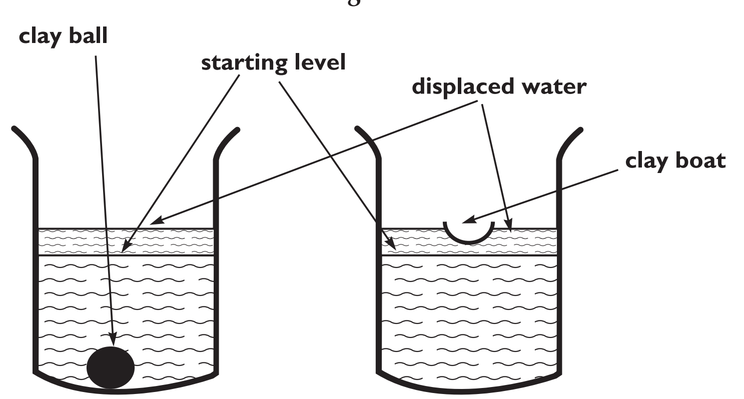


Diagram A6

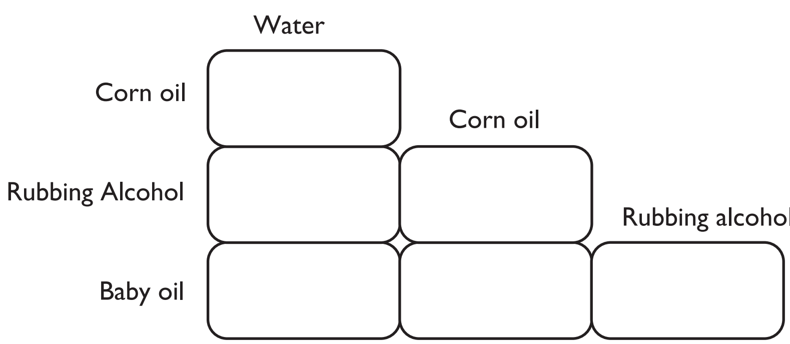
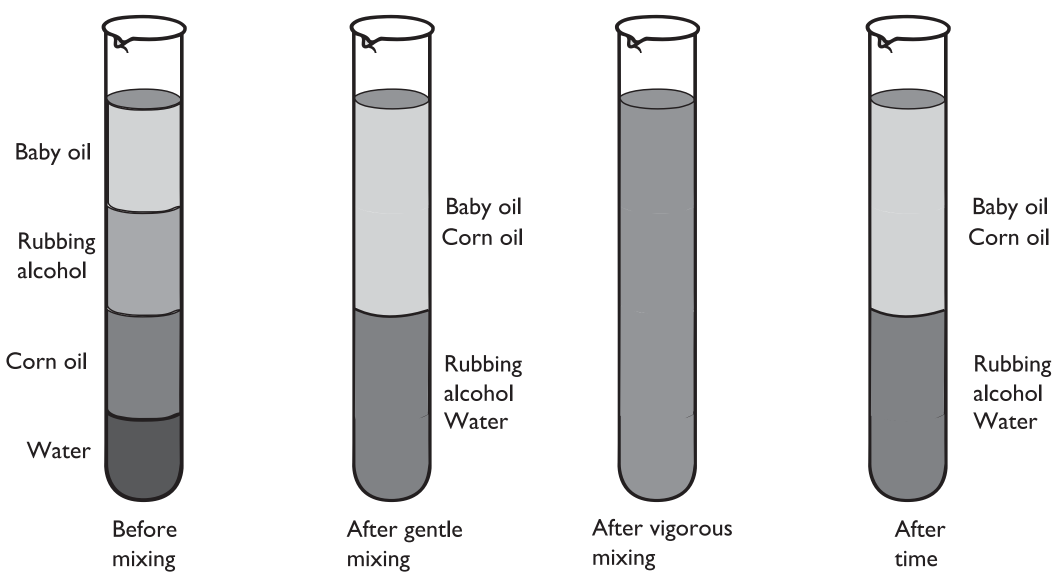


Diagram A7



21. Frozen Expansion: A Unique Property of Water

Equipment Needed

A freezer, small containers—one for each of the substances to be tested (dosage caps from cough medicine bottles work well), a source of heat; suggested substances in addition to water: paraffin, moth balls, Vaseline, butter or shortening.

Purpose

To demonstrate a unique property of water—that water expands as it freezes while most substances contract

Safety—Special Considerations

When heating a substance to cause it to liquify, be sure to have adequate ways to handle the heated materials. Use a hot plate on low (no open flame) to melt small amounts of the materials. All of these are organic compounds and can ignite. A water bath, a container with material to be melted placed into water in a larger container, can be used to promote even heating. Use Pyrex® containers when melting all materials. Do not heat the substance far past melting; only enough to keep the substance liquid during transfer and measurement. Do not boil or fill the room with fumes. Do not substitute other substances for this activity such as alcohol or other solvents. Uncovered volatile (quick to evaporate) substances can explode inside a regular refrigerator or freezer. This is very dangerous.

Grade Level—Time Needed

Middle to upper elementary; younger grades at teacher's discretion; Time: two class periods: one class period to prepare the materials, and sufficient time for all of the substances to freeze (solidify); plan on completing the project the next class period.

Background

While water is the most common substance on earth, it has some very unique and distinctive properties. Water appears on the earth as a solid, a liquid, and a gas. No other substance appears in these three forms within the earth's normal range of temperature. Most substances contract as they grow colder. But when water is cooled, it contracts only until its temperature reaches 4° C (39° F). At 4° C water starts expanding until it is about 9% larger. If water contracted upon freezing, any volume of ice would be heavier than an equal volume of liquid water. Ice would then sink. If ice sank, the earth would become a lifeless arctic desert. Each winter more and more ice would pile up in the bottom of lakes, rivers, and streams. In summer, the sun's heat could not reach deep enough to melt the ice. Water life would die. The hydrologic cycle would slow down. In time all of the water in the higher latitudes would turn to solid ice, except perhaps for a thin layer of water over the ice during the summer.

Water is a liquid at temperatures found in most places on the earth. No other common substance is liquid at ordinary temperatures. In fact, the temperatures at which water is a liquid are unusual. Water is a liquid between 0° C and 100° C (32° F and 212° F). Most other substances with a structure like that of water (H_2S is a good example) are in the gaseous state in this temperature range.

Procedure

This activity may be done by the teacher as a demonstration or by older children as a small group activity.

Liquify enough of each solid to fill a container. Follow the safety considerations for melting substances. Using each of the substances, fill the plastic dosage caps. Label each substance. Place the labeled containers into a small tray and place them into a freezer. Put a thermometer in the freezer to determine that temperature. The next day remove the substances from the freezer. Check each substance for contraction or expansion and whether the substance froze.

Record the results on the data sheet.

Assignment

Complete the worksheet. Encourage the students to suggest other substances to test, but warn them about the danger in testing a volatile substance inside a freezer. Avoid volatile substances.

Family Involvement

Freeze a plastic bottle or cardboard carton filled with water. Draw a picture of the result. Explain what happened. Search for other substances to test which do not contain water or is mostly alcohol. (Alcohols will freeze but most of them freeze at a lower temperature that is not possible to attain with a household freezer or even in polar regions. Hence they are used as antifreezes.)

Include a prayer of thanksgiving for the precious gift of water in your family devotions.

Discuss why, when liquids are to be frozen, containers should not be filled to the brim.

Christian Application

When God created the world, he displayed both his omniscience and his almighty power. Although water is the most common substance on earth, God gave it properties which are most important and unique. It was not an accident that God created water with these properties because they are so very vital to all life on earth.

Extension

Suggest and test other substances. Prepare some freezer jelly. (Recipes are readily available.) Be sure not to overfill the containers.

Have a muffin and jelly party. Invite another class to join you.

An interesting extension for upper grades is to use an unusual material with a low melting temperature metal such as Wood's metal which melts at 75 degrees C. Wood's metal is available from science suppliers such as Frey Scientific and Cenco Science.

References

Leopold, Luna B. and Kenneth S. Davis. *Water*. Life Science Library, New York: Time Incorporated, 1966, pages 8-30.

Davis, Kenneth S. and John A. Day. *Water: The Mirror of Science*. New York: Anchor Books, 1961, pages 17-36.

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Frozen Expansion

Temperature in the freezer: ____°C

Name of Substance	Expanded	Contracted	Same or can't tell	Freeze solid

Which substance(s) expanded? ______________________________

____

Which substance(s) contracted? ______________________________

____

Which seems to be normal, expansion or contraction? ______________________________

Which substance(s) is/are different? ______________________________

____

22. Indirect Evidence of the Earth

Equipment Needed

Different types of spheres for each student or group. Suggested types might include golf balls, basketballs, baseballs, rubber playground balls, and tennis balls and one set of spheres which has been cut in half.

Purpose

To show that much can be learned by inference about what lies beneath the Earth's crust by observing the crust of the Earth

Safety—Special Considerations

Students should not cut the spheres open. One set for teacher demonstration is adequate. If the activity is done in the classroom, students will need to restrict their discovery activity to a level which is safe within the classroom. The cutting of the demonstration set of spheres should be done with care using ordinary hand saws. Cutting round objects with a power saw is very dangerous unless done only by someone very skilled in the use of such equipment. Therefore the use of power equipment is strongly discouraged.

Grade Level—Time Needed

Grades 4-9; Time: one class period

Background

Many students will infer what is inside of the spheres by observing them from the outside. Scientists use this same type of method to provide information about the inside of the Earth. Earthquakes, mountain building, geysers, volcanoes, and hot springs provide external clues to the Earth's interior.

Procedure

This activity can be done in groups, individually, or as a teacher demonstration. Distribute the different types of spheres to each student or group. Instruct students to examine each sphere and write down what they think is inside the ball. Students should provide a reason for their answers. Have the students share their guesses about what is at the center of each sphere, and the reasons for making their guesses. Display the spheres which have been cut in half. Compare the spheres with the students' guesses. Discuss the nature of making inferences. *Could scientists make mistakes?*

Assignment

Display a diagram of the Earth which shows Earth's inner layers, and the main characteristics of each. Construct a poster to show, and describe the inner layers of the Earth. *Has anyone seen these layers?*

Family Involvement

Have each student place an item into a paper bag. Staple the paper bag and send it home. Students should encourage family members to guess what is in the bag through external observation and touch.

Christian Application

Only God knows what is really at the center of the Earth. The Lord has created a planet which continually rotates on its axis, and renews itself through processes shown by the rock cycle. Man tries to learn about God's creation both by direct and indirect observation.

Extension

Have students research the diameter of the Earth. (12,756 km at the equator) Encourage them to write word problems about the Earth's diameter. For example, if you can dig a hole through the Earth at a rate of 2 km a day, how many years will it be before you reach the opposite side? Write a story about what problems you might encounter if you would dig such a hole.

References

Verne, Jules. A *Journey to the Center of the Earth*. New York: Dodd, Mead, 1959.
Cole, Johanna. *The Magic School Bus: Inside the Earth*. New York: Scholastic, 1987.
Raymo, Chet. *The Crust of Our Earth: An Armchair Traveler's Guide to the New Geology*. Englewood Cliffs, NJ: Prentice-Hall, 1983.
Miller, Russell. *Continents in Collision*. Alexandria, VA:Time-Life Books, 1983.

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Indirect Observation of Interiors of Spheres

Type of Sphere	Your hypothesis for the interior	Evidence

Questions

1. What conclusions did you reach about indirect observation?

2. What conclusions did you reach about indirect observation of the Earth?

23. The Earth's Magnetic Field

Equipment Needed

Iron filings, self-sealing sandwich bags (sandwich size or larger), pieces of tagboard to fit under the plastic bags, bar magnets, circle magnets, metallic spoon.

Purpose

To demonstrate the shape of a magnetic field around magnetic materials; to help students visualize the magnetic field which surrounds the Earth

Safety—Special Considerations

Students work in groups of 2-4. Try not to open the bags or spill the filings. Do not let the iron filings get on the magnets. Iron filings are tiny pieces of metal. They are sharp, and care must be taken so they do not get into students' eyes, mouths or food. Instruct students that the filings may stick to their fingers. Students should be careful about putting their hands to their faces, or rubbing their eyes while doing this experiment.

Grade Level—Time Needed

Grades 1-8; Time: 30 minutes

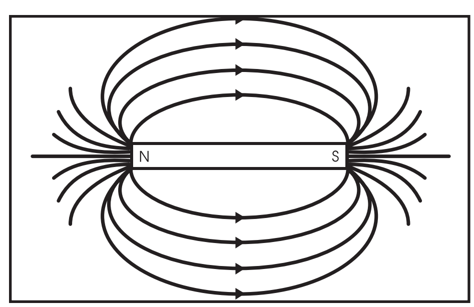
Background

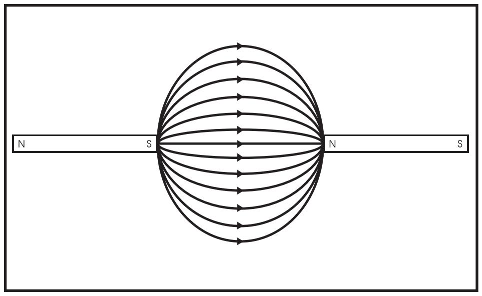
The Earth acts like a magnet with a surrounding magnetic field, the magnetosphere. The magnetosphere extends far into space. On the side of the Earth which faces the sun, the magnetosphere reaches about 4000 km into space. On the opposite side from the sun in a tail-like fashion, the solar winds stretch the magnetosphere thousands of miles into space.

The magnetosphere protects the Earth from harmful electro-magnetic radiation given off by the sun. This radiation, if not deflected, would be very harmful to life on Earth. However it is deflected by the Earth's magnetic field, and held in an area called the Van Allen radiation belt. Sometimes, when the sun is very active, the magnetosphere is bombarded with charged particles from the Sun. Some of these particles slip through the magnetosphere and interact with other charged particles. These interactions in turn radiate visible light. This shimmering light is very beautiful and multicolored. These lights originate from and pulsate across the sorthern horizon. We call them Northern Lights, or Aurora Borealis. If you lived in the Southern Hemisphere, you would call them southern lights, or Aurora Australis because they would seem to come from the South Pole.

Procedure

Place a tablespoon full of iron filings into the self-sealing plastic bags before class begins. Seal the bags. Lay one bag flat on the tagboard. Carefully place the tagboard, with the plastic bag, over a bar magnet. Tap the tagboard, or shake the bag gently to spread the filings around. *What do you see?* Now try two magnets. *Is the resulting magnetic field the same? What happens if you lay two magnets side by side, but one with the north pole pointing towards the top of the desk, the other with the south pole pointing towards the top of the desk?* Try the same with a circle magnet. *What does the resulting filing pattern look like?* Lay the two magnets end to end.

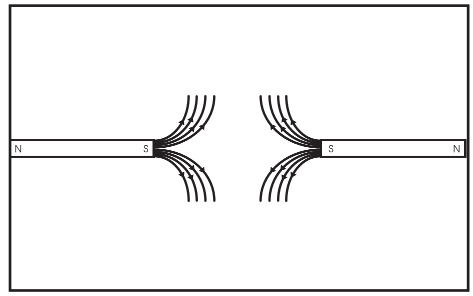


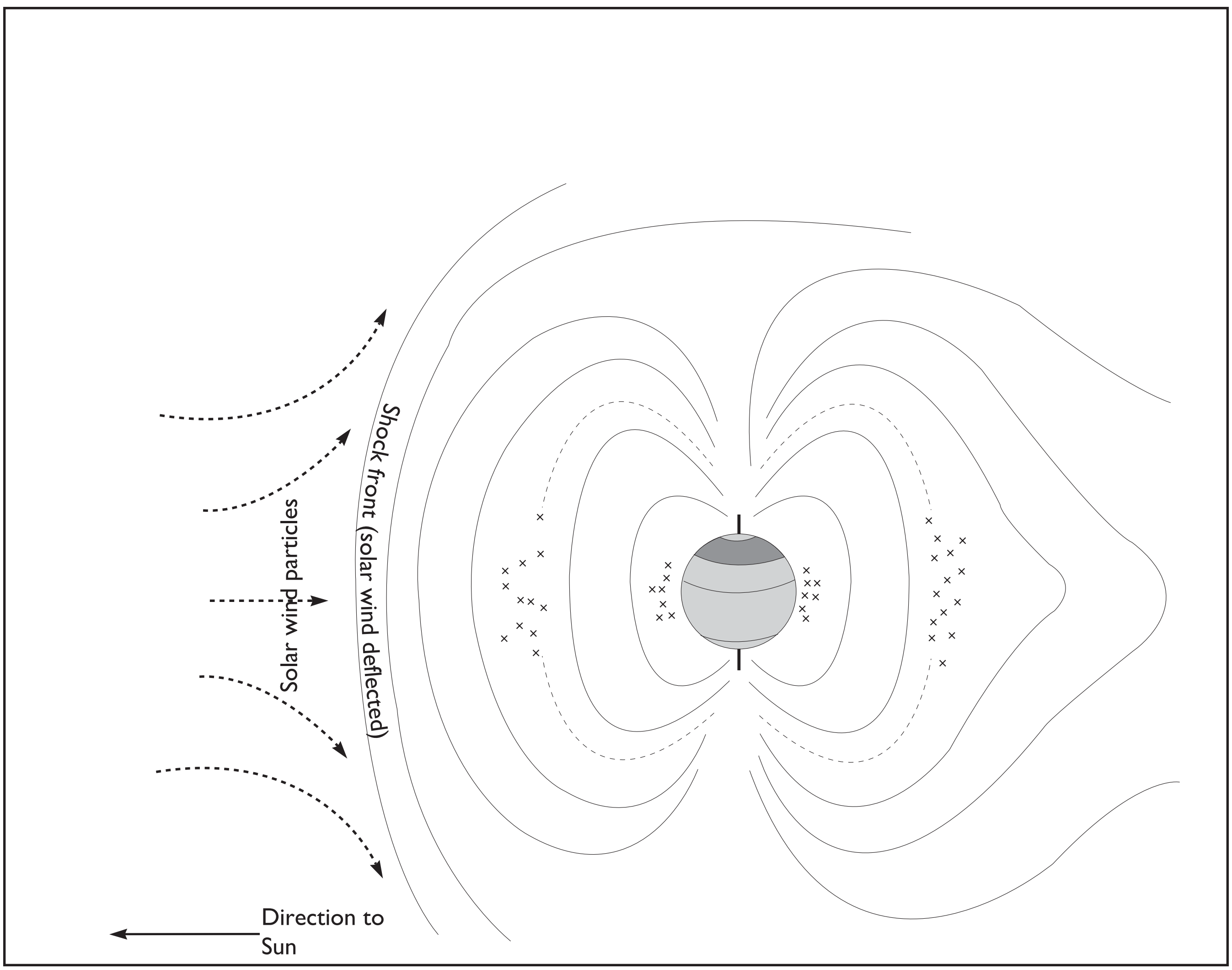


Put the north poles facing, but not touching, each other. Do the same with the south poles. Now, place the magnets so that one south pole and one north pole face, but do not touch each other. *Describe what you see. What does this suggest?*

You may need to adjust the amount of filings in the bag. If there are too many, most will lump together very close to the magnet. If you do not have enough, you will have trouble seeing the magnetic field.

To help students understand that the Earth's magnetic field is really 3-D, see the section on magnetism, The Biggest Magnet of All: Earth. You might also try mixing some filings and vegetable oil for a more pronounced 3-D effect.





Assignment

Draw and label diagrams of the magnetic fields you made using the bar magnets. Describe what you think a magnetic field is.

Teacher information: An invisible force emanates from one pole of the magnet and returns to the other. The magnetic field is always most concentrated at the poles. The field is part of a theory in which scientists believe. The field can only be measured indirectly.

Family Involvement

Tape recorders use magnetic tape to create recordings. Use a blank tape to record members of the family. Remove the tape from the recorder and place a strong magnet and the tape into the same box. Listen to the tape the next day to see what effect the magnet has had on the tape.

Christian Application

The Earth and the Sun are but only a small part of God's creation. The Sun provides energy for our world, and sustains all life on Earth. As the Sun shines, it radiates energy in the form of visible light and very small charged particles.This radiation can be harmful to life on Earth, both plant and animal. The magnetic field which surrounds the Earth is seen to protect us from some of the harmful effects of this radiation. The Earth's magnetic field is thought to arise from the rotational motion of its molten core which God placed at its center. In this way the Earth's magnetic field is most beneficial to life on Earth.

Extension

Magnetize a large steel needle by stroking it in one direction only with a very strong magnet. *Now what happens if you lay this needle under the bag of iron filings? What may be suggested by the behavior of the iron filings?* (The existence of something we call a force field, the concept of direction, and concentration) (For the teacher: The concept of a force field is difficult to understand. Our understanding today is limited to the concept of a space whose properties are altered by some force.)

References

Earth Science. Englewood Cliffs, NJ: Prentice-Hall,1984.
UNESCO. *700 Science Experiments for Everyone.* Garden City, NY: Doubleday, 1958.
VanCleave, Janice. *Magnets.* New York:John Wiley & Sons, 1993.
Ward, Alan. *Experimenting with Magnetism.* New York: Chelsea House Publishers, 1991.

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24. How Does Gravity Cause the Earth to Revolve Around the Sun?

Equipment Needed

Large press board, or plywood square, 24" x 24"; carbon paper; steel ball, or other heavy sphere; ruler; 18" X 24" white paper; tape

Purpose

To represent the force of gravity on a forward moving object

Safety—Special Considerations

This activity should be done in pairs, or threes. Each student will need enough space to prop the data board against a wall. Take care this activity is done in an area where rolling spheres will not be a problem. Not all types of carbon paper will work for this activity. Be sure to check this out.

Grade Level—Time Needed

Grades 4-8; Time: 10 minutes, plus discussion

Background

Forward moving objects like a sphere continue to roll forward in a straight line unless something stops them. Gravity pulls a thrown ball towards the surface of the Earth. As the ball continues to move forward, and falls to the Earth at the same time, an arc is traced.

As the Earth is moving through space, the Sun, at the same time, is attracting the Earth towards its center. The Earth falls toward the Sun while at the same time it moves rapidly forward in a curved path about the Sun.

Procedure

Tape a sheet of white paper in the upper right hand corner of the data board as shown in the diagram. Cover it with carbon paper, face down. Lean the board against the wall at about a 45 degree angle. Hold a ruler against the upper left hand corner of the board to create a rolling track. Roll the sphere along the ruler which will let it fall down and roll in a curved path over the carbon paper.

Ask the students: *Did the ball continue in a straight line after moving past the ruler?* (No) *What kind of path did it make on the white paper?* (Curve) *What force caused the ball not to follow a straight line?* (Gravity)

Assignment

Do research to find out how long it takes the Earth to travel around the Sun. ($364\frac{1}{4}$ days) Find the same information about other planets. Compare the distance the Earth travels in a year to that of other planets, for example, the distance Pluto travels in a Pluto year. Can students find a scale they could use to draw lines, or cut lengths of string to show the difference?

Family Involvement

Take several different kinds of balls to a play area. Have one member of the family throw a volleyball or basketball forward in the air. Other members of the family should trace the path of the ball with their fingers. Do all balls have the same arc? Does the way a ball is thrown make a difference? Try different family members. Does height make a difference? For variety, try launching the balls in different arcs.

Christian Application

God's world is not a haphazard arrangement. It is well planned, and all its parts work together. God uses the plan he set up at Creation to bring about natural phenomena. When we try to interpret God's plan, we devise laws that describe what we see.

It is important that the Earth remain near the Sun. However the movement of the Earth around the Sun creates a force which matches the pull of the gravity of the Sun, so the Earth continues to move in such a fashion that it maintains the same average distance from the Sun. We conclude from our point of view that the force of gravity keeps the Earth moving in the same average circular path about the Sun. Ask the students, *Who put the earth in motion? When?*

Extension

Save the paper from this activity, and use it as an art project. Have the students trace over the carbon paper lines with a colored marker and then use the resulting lines as part of a picture. If some students' papers become smudged, let them try again with clean paper.

References

Gamow, George. *Gravity*. Garden City, New York: Anchor Books, 1962.
Narlikar, Jayant V. *The Lighter Side of Gravity*. San Francisco: W. H. Freeman, 1982.

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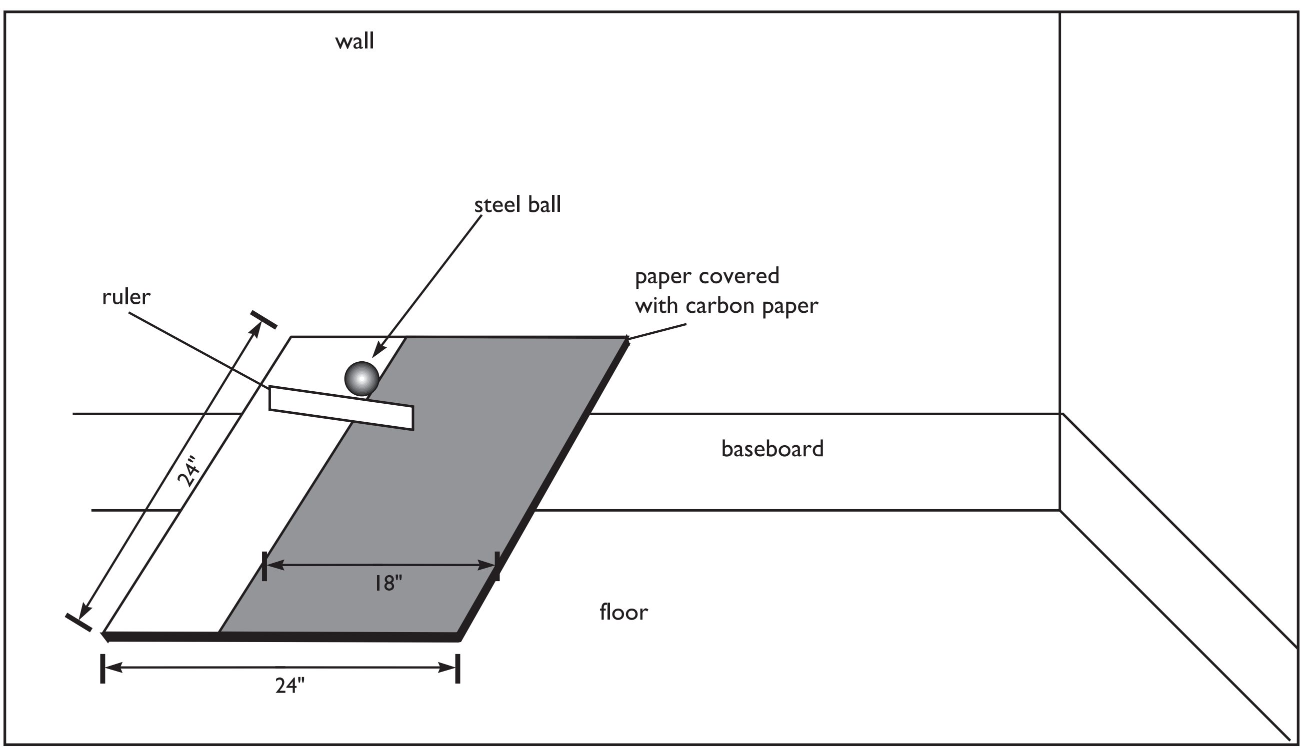

25. Direct Evidence of the Inner Earth

Equipment Needed

Map of the world for each student, Styrofoam trays from bakery or produce, single-edged razor blades or scissors, 9" x 13" pans, or larger Styrofoam trays, hot tap water, cold tap water, straw or eye dropper.

Purpose

To show students how the continents of the Earth fit together like a puzzle, suggesting they were at one time a large, single landmass called Pangaea, a model of continental drift

Safety—Special Considerations

Use the appropriate cutting tool for group. Younger groups should use scissors, which will make matching the edges a little more difficult, but not impossible. This will not detract from the experiment. The pieces will not fit together exactly, because sea levels may have risen, and erosion has changed many parts of Earth.

Use Styrofoam trays from bakery and produce—be sure to wash them first. Do not use trays from meat products, for this may spread disease. Many grocery stores will give you a handful of these trays; others sell them for a minimal amount.

When cutting with the single-edged razor blade, make sure that you cut on cardboard or something similar to protect the desk or table.

Grade Level—Time Needed

Grades 5 and up; Time: one class period for older students, younger students may need two

Background

Many scientists believe all the continents were once joined as one large landmass, which then broke apart and drifted to their present locations. The large landmasses that hold the continents are called techtonic plates. Mountain ranges, rocks, and fossils all offer evidence of continental drift. Scientists believe the continents move because of convection currents in the upper part of Earth's mantle.

As the plates move, some push against one another at the boundaries. Other plates spread apart, a few slide past each other, and sometimes one plate moves over the top of another. Different types of boundaries are convergent/colliding (plates moving toward each other), divergent/spreading (plates moving away from each other), and transform faults/shearing (plates which are sliding past each other). The movement of the plates causes seismic activity (earthquakes) and volcanism (volcanoes) throughout the world mainly along plate boundaries.

Procedure

Have students cut out the continents and other large land masses from the world map. They should then use these as patterns to cut matching pieces from the Styrofoam trays. Let the students figure out how the continents fit together on a stable surface. Students may find more than one way. This is okay; even scientists do not agree on this.

Next place a thin layer of hot tap water into the large Styrofoam tray and assemble the continents on top of the water. *What happens if the tray is moved? What happens if you push South America towards Europe?* While the water is still warm, use a straw or eve dropper to drop cold water into the hot water. Does this make the pieces move? *Do all the pieces move in the same direction? Do any of the pieces move on top of other pieces?*

Assignment

Walk around the school and observe the cracks in the sidewalk, buildings, and soil. Describe the cracks, and tell what you think made the cracks. Hypothesize why the large landmass, Pangaea, broke apart to form the tectonic plates.

Family Involvement

Read *A Journey to the Center of the Earth* by Jules Verne or view the video based on it. Discuss what parts of the story could be true and what parts are not true. Younger children might enjoy *The Magic School Bus :Inside the Earth,* by Joanna Cole.

Christian Application

God separated the land from the waters the third day of creation. The Bible does not tell us if all the land was in one place, or spread about the globe as it is now. If there was a large landmass, it could have broken apart during the flood. Genesis 7:11 tells us that water burst forth from deep within the ground, as well as poured down from heaven. Such force would do great damage to the Earth. Moreover, the weight of water above the ground would have caused the Earth's crust to buckle in weaker spots, and perhaps break. We do not know if there was one large landmass, but we also cannot say there was not. Even if a theory agrees with the Bible, we cannot tell if it is true.

Extension

Study convection currents in other contexts. Fill a small plastic cup, or clear jar one half full of clear warm water. Use a straw or eye dropper to drop colored cold water down the side of the jar. Observe what happens.

Next, fill the plastic cup one half full of clear cold water. Use the dropper to drop colored warm water down the side of the jar. *Does something different happen?*

When matter of one density meets matter of another density, convection currents occur. The more dense matter falls to the bottom and the less dense rises to the top. In this case, the differences in density are caused by amount of heat.

References

Verne, Jules. *A Journey to the Center of the Earth*. New York: Dodd, Mead, 1959.
Cole, Johanna. *The Magic School Bus: Inside the Earth*. New York: Scholastic, 1987.
Raymo, Chet. *The Crust of Our Earth: An Armchair Traveler's Guide to the New Geology*. Englewood Cliffs, N.J.: Prentice-Hall, 1983.
Miller, Russell. *Continents in Collision.* Alexandria, V.A.:Time-Life Books, 1983.

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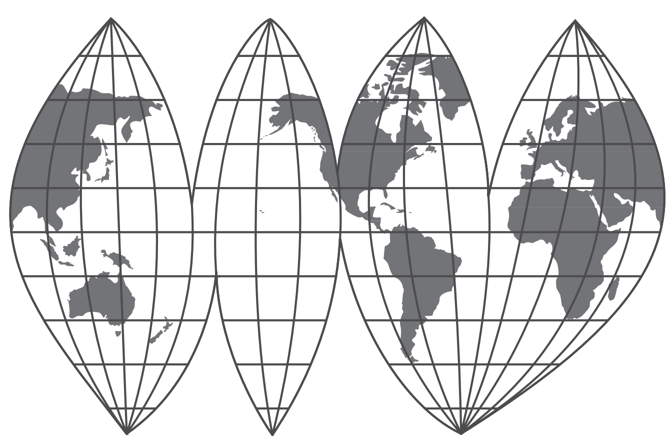

26. The Biggest Magnet of All: Earth

Equipment Needed

A bar magnet which has the N pole clearly marked, a 24" piece of string, a compass

Purpose

To illustrate that Earth behaves in the same manner as a very large magnet

Safety—Special Considerations

Suspend the magnet away from metal objects, or the metal may be attracted to the magnet. If the magnet is suspended at eye level, students should be careful not to walk into it.

Grade Level—Time Needed

Grades 1-8; Time: 20 minutes

Background

Substances have magnetic properties because of the manner in which electrons spin within a given material. Some magnets, called lodestones, occur naturally; others are man made. Earth behaves as if it were a magnet, pulling the north pole of the suspended bar magnet towards Earth's northern geographic pole. The suspended magnet aligns itself with Earth's magnetic field. Any compass is really a small magnet which aligns itself with the magnetic field of Earth. Scientists have many theories of why Earth behaves this way. Some feel there is a core of molten iron and nickel at the center. Others say currents flowing through the core of Earth act like an electric current. (Any flow of electrical charge is always accompanied by a surrounding magnetic field.)

Procedure

Instruct students to locate the north wall of the classroom using the compass. If a compass is not available, label the walls of the classroom with appropriate directions (N, E, S, W) before class begins. Distribute magnets and string. Tie the piece of string securely around the center of the magnet. Suspend the magnet so that it turns freely. Gently twist the string. Allow the magnet to come to a complete rest. *Which pole points towards the north wall of the classroom?* (N) Suspend two magnets near each other. *Do they still point toward the north wall of the classroom, or do they attract or repel each other?* (Attract) *Do opposite or like poles attract?* (Opposite) *If the N end of a magnet is attracted toward the North Pole of Earth, then what really is Earth's North Pole?* (Magnetic S)

Assignment

Many of the explorers who traveled the world in the 14th and 15th century were sure they could find their way home using a magnetic compass. It is wise to find out how these compasses work. *Why are magnetic compasses no longer used on ships? What kind of compass has replaced them?*

Family Involvement

Use a sheet of tagboard to create a game. Use steel pins, needles, or other metal objects. Place a magnet underneath the cardboard and use the magnet to make the pins race to the end of the board. Try objects of different sizes. Does the size make a difference in the way the magnet moves it?

Christian Application

God's gifts come to us in many ways. Magnetic materials are used in telephones, generators, medical equipment, computers and even to keep cows healthy. Inventors and scientists find new ways to use natural materials which God placed in the world at Creation.

Extension

Cover a bulletin board with plain paper. Have students research magnets and find unusual uses for them. Encourage students to write their discoveries on the bulletin board with markers or post their printed reports on notecards. You might begin the list with this type of note: Small particles of iron chip off the machinery during food production. In order to keep the food healthy for us, magnets are used to keep the iron particles from mixing with the food.

References

Van Cleave, Janice. *Magnets*. New York: John Wiley ,1993.
Ross, Frank Jr. *Oracle Bones, Stars, and Wheelbarrows*. Boston: Houghton Mifflin, 1982.
Ward, Alan. *Experimenting with Magnetism*. New York: Chelsea House, 1991.

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27. Magnets: Finding the North or South Pole

Equipment Needed

A magnet and at least one compass for each group, if available

Purpose

To find how a magnet is polarized

Safety—Special Considerations

Normal lab safety procedures should be followed. On some cheaper compasses the arrow does not always point north. It may point south. Also a magnet may lose its magnetism or its poles may be reversed if it has been heated, dropped, struck with a hard object, or exposed to another magnetic force.

Grade Level—Time Needed

Any grade level; Time: 15 minutes

Background

Chinese legend has it that the first use of a magnet as a direction telling device dates back to 2637 B.C. The Emperor Hoang-ti used it to tell direction in a dense fog while pursuing a rebellious prince. The use of a lodestone as a compass did not appear in Europe until well into the 10th century. Lodestones were first studied scientifically in the thirteenth century.

Procedure

Have the students hold their compasses so that they are separated from each other and any magnets that may be in the vicinity. Ask them which end of the balanced needle points geographically north. Record their observations. Next place a magnet on a sheet of paper. Place the compasses around the magnet. *What do the compasses show us about the poles of magnets?* The north end of the compass will point to the *south* pole of the magnet. The south end of the compass will point to the *north* pole of the magnet. (See note below.)

Assignment

Write a report summarizing your results stating which poles were attracted and which poles were repelled. Draw a diagram showing the magnet and the position of the compass needle with the compass at various locations around the magnet.

Christian Application

Just as a compass can help us find a location on this earth, the Word of God is like a compass. The Word points us to faith in Jesus Christ which is the only true way to find our heavenly home.

Extension

Use two magnets end to end or side by side and try the same thing. Stand the magnet on end and place the compasses around it. Turn the magnet on its side.

References

Graf, Rudolf F. *Safe and Simple Electrical Experiments, #42*. New York: Dover, 1964.
Furry, W.H., E.M. Purcell and J.C. Street. *Physics for Science and Engineering Students*. New York: Blakiston, 1952.

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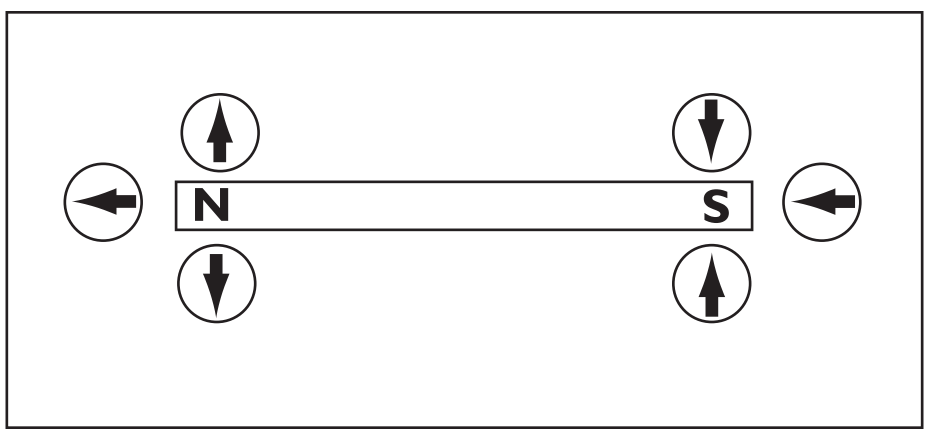
NOTE: There is some disagreement about naming the poles of magnets. English speaking countries speak of the north seeking pole as the north pole or N and likewise for the south seeking pole as a South pole or S. Thus the magnetic north pole of the Earth, by convention, is a south seeking pole which attracts the north seeking pole of a magnet. In France the opposite convention is used. They say the north seeking pole of a compass, N, is really a south magnetic pole which is attracted to the north magnetic pole of the Earth. Both conventions make sense and yet have some confusing aspects. We will follow the convention used in English-speaking countries.



28. What is Gravity?

Equipment Needed

Various lengths of string (all students do not have to have the same length), weights to attach to the string (Use a variety of weights: a short pencil, paper clips, washers, piece of cardboard, etc.), a ruler, masking tape, a large sheet of paper, two different colored markers

Purpose

To demonstrate that the pull of gravity is directed towards Earth's center

Safety—Special Considerations

General safety precautions should apply. Use a butcher paper or a double sheet of paper which will prevent the markers from bleeding through to the wall. Use areas of the wall which do not have strong air currents to blow the string. Be sure students concentrate on the experiment, and that each has enough room to work. This activity is best done in pairs.

Grade Level—Time Needed

Grades 3-8; Time: 15 minutes

Background

Gravity is a force which pulls objects on or near Earth's surface towards Earth's surface. The pull is directly toward the center of Earth. Other objects in space are sources of gravity. The gravity of the Sun keeps Earth in orbital motion. The gravitational pull of the Moon affects tides on Earth. The amount of matter affects the amount of gravity. The gravity of the Moon is one-sixth that of Earth. The gravity on Jupiter is about 3.5 times that of Earth. This means your weight on the Moon would be one-sixth of your weight on Earth and on Jupiter you would weigh 3.5 times more than you do on Earth.

Although we agree that gravity is a force between any two objects, we do not have a clear picture as to what it may intrinsically be. Aside from its measured properties, gravity remains a fundamental mystery of nature.

Procedure

Distribute pieces of string, paper and tape to each pair of students. Instruct the students to choose a weight and tie it securely to the bottom of the string. Next tie the top of the string to the center of the ruler. Tape the paper securely to the wall. Instruct one student to hold the ruler next to the paper as level as possible. Have the second student use one color marker to draw a line under the rule, and the second color to draw a line parallel to the string. Move the ruler to another position. Try slanting the ruler. Have the second student make markings along the ruler and the string as before. Remind the student to use the same color for the ruler each time. Let students try holding the ruler in several different positions, marking each position.

When the students have finished, they will have a visual aid which clearly demonstrates that the weighted string will hang straight down, no matter how the ruler is held.

Let students display their string length, the weight used, and the resulting visual aid. Ask students *Does the length of string makes any difference?* (No). *Does the weight make any difference?* (No).

Assignment

Research other celestial bodies. Make a chart which shows the gravity of the celestial bodies that you have researched. Don't forget about stars and apparent black holes. *Can you find out what kind of object in space has the most gravitational attraction?* (black holes)

Family Involvement

Take a walk around the neighborhood. Observe how gravity affects the world around you. Look at telephone wires, hillsides, trees, plants, people's hair and clothing, and clothes hanging on the line. Are there other similar examples of gravity at work?

Christian Application

Gravity affects our lives in many ways. It not only keeps us from flying off into space, but also makes it possible for planes to land, and water to come out of the faucets. When astronauts are in a state of weightlessness in space there are many changes in their bodies: bones lose calcium; their muscles, including their hearts, shrink; their kidneys have to work harder. God is all-knowing and he created the world with gravity and the forms of life in it to complement this force.

Extension

Sir Isaac Newton is generally credited with formulating the first theory of gravity. He built upon the work of J. Kepler, G. Galileo and others. We now believe that gravity is a force that attracts all objects depending on mass and distance. Pretend that you were an ordinary or even an educated person that lived during the 17th century. How would you have reacted to these new ideas?

References

Gamow, George. *Gravity*. Garden City, New York: Anchor Books, 1962.
Narlikar, Jayant V. *The Lighter Side of Gravity*. San Francisco: W. H. Freeman, 1982.

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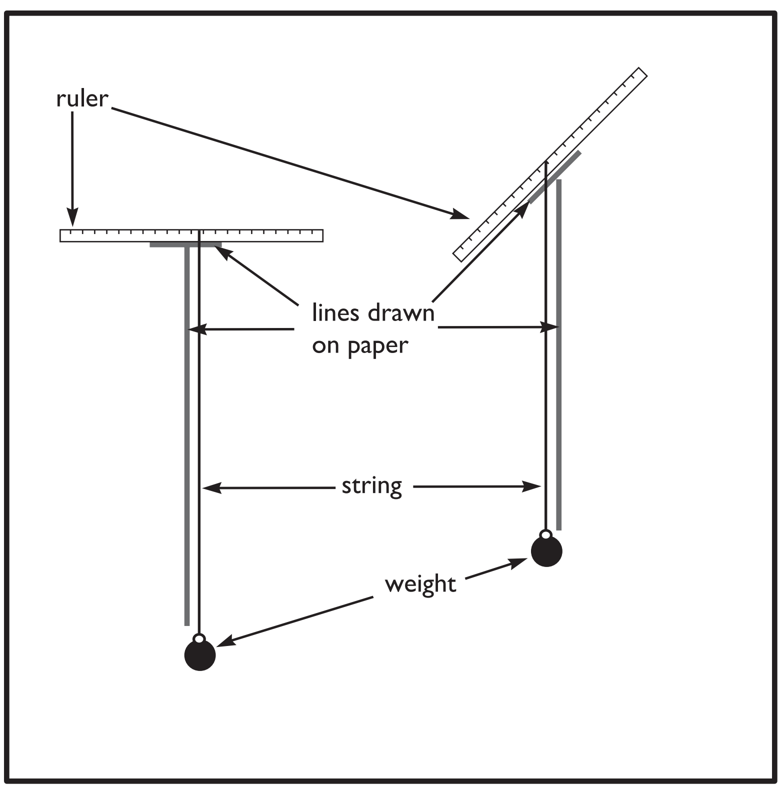

29. Volcanoes, What is the Plasticity of the Earth's Mantle?

Equipment Needed

Three oz. plastic cup, cornstarch, water, plastic spoon, (optional: red food coloring and wax paper) for each group

Purpose

To demonstrate that sometimes materials are liquid or solid, depending on the amount of pressure placed on the material

Safety—Special Considerations

Have fun with this. Don't worry about the clutter that may develop. When students are finished playing with it, the material can easily be cleaned from the desk and returned to the cup. Some of the material may dry; it can easily be swept or vacuumed away. If in doubt about the surface or mess, use wax paper squares to protect the surface. Be careful when handling the food coloring for it can stain fingers and clothing temporarily. This is especially true on lighter colored clothing. Most food colorings wash out without any trouble if the garment is first soaked in cold water.

Grade Level—Time Needed

Grades 3-9; Time: 20 minutes, plus discussion time.

Background

The mixture acts like a solid when pressure is put on it. Without pressure it acts like a liquid. The material in the Earth's mantle acts in a similar manner. The material in the mantle is mostly molten when there is little pressure exerted on it. If the pressure increases, the material behaves more like a solid. Volcanoes develop when large magma pools of molten rock form just below the Earth's outer crust. The molten material gives off gases. As the gas pressure builds up, it reaches a point where it must escape. At this point a fissure develops and the volcano erupts, throwing molten lava, steaming water, mud and rock debris high into the air.

Procedure

Fill the cup about $^2/_3$ full of cornstarch. Observe the cornstarch. *What are its properties?* Add water to the cornstarch, a little at a time, and mix with the spoon. Add a few drops of food coloring for effect if you wish. Add water a little at a time until all of the cornstarch becomes wet (viscous), but not runny. It should be difficult to stir. Older students may measure the amounts of cornstarch and water needed to reach the desired outcome.

Use a pencil, or the tip of the finger and push down hard on the mixture. *What happens?* Next gently place the pencil on top of the cornstarch mixture, and slowly let it go to the bottom. Pour the mixture onto the desk. *Is it a solid or a liquid?* Pick the material up and make it into the shape of a sphere. *Can you break off a piece of the mixture?*

Assignment

Using encyclopedias and other sources, research the nature of the various magmas. Compare and contrast the cornstarch mixture to the material in the Earth's mantle.

Family Involvement

Suggest that students take the mixture home. If it becomes dry, just add a little more water. Use the cornstarch mixture to explain to family members how the magma in Earth's mantle behaves.

Christian Application

The inner workings of Earth are a mystery to mankind, but are known to God. Each part of Earth, including its interior, is an important part of God's plan for making our Earth a suitable place for us to live. God created Earth in an orderly manner. His creation demonstrates his unfathomable wisdom, his orderliness, and mostly his concern for us.

Extension

Silly putty is another mixture which behaves in a similar way. Read how silly putty was discovered ("How the Lifesaver Got its Hole," *Readers' Digest,* August, 1995). For older students, obtain some "lava rock" from a landscape or garden shop. This rock is full of holes caused by escaping gas bubbles. Have the students examine samples of the lava rock and discuss the origin of the holes.

References

Radlauer, Ed and Ruth Radlauer. *Volcano Mania.* Chicago: Children's Press, 1981.
Simon, Seymour. *Volcanoes.* New York: Morrow Junior Books, 1988.
Gray, William R. et al. *Powers of Nature.* Washington , DC: National Geographic Society, 1978.

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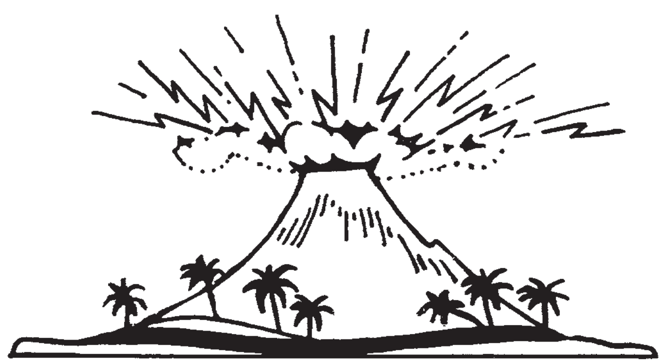

30. How Does a Volcano Work?

Equipment Needed

One aluminum pie plate or other shallow pan, a medium sized, heat resistant funnel, three small blocks of wood (or metal bottle caps), a hot plate, a cardboard box large enough to fit over the hot plate and to allow the funnel to poke through a hole which has been made in the center of the bottom.

Purpose

To simulate the build up of gas pressure which causes a volcano to erupt

Safety—Special Considerations

Hot steam will be emitted during this demonstration. Be sure children stand away from the demonstration. The steam will be hot enough to cause severe burns. **This caution should not be ignored!**

Grade Level—Time Needed

Grades (**Teacher Demonstration only.**) 4-12; Time: 10 minutes

Background

When water in a pan is heated and boils, it expands and changes to a gaseous state; this condition we call water vapor. As the water vapor forms, pressure increases under the funnel and forces the water out of the top, since this is the easiest and only way for the pressure to escape. When the heat and pressure are relieved, the eruption of water and steam lessen and finally stop.

Volcanoes work very much in a similar way. Hot molten magma beneath the Earth's surface releases gases, and sometimes heats near-by trapped water, causing it to change into steam. As steam pressure builds, molten lava is forced from the cone of the volcano.

Procedure

Fill the pie plate about half full of water. Arrange the bottle caps on the bottom of the plate, and support the inverted funnel on them. Place the pie plate on the hot plate. Heat the water in the pie plate until it starts to boil. Then, place the inverted box over the inverted funnel, allowing the funnel tip to protrude through the hole which has been cut into the bottom of the box. Watch from a distance as steam and hot water begins to spurt out through the top. This demonstration can also be used to simulate the action of a geyser.

Assignment

Using appropriate research materials, have children work in small groups to find a list of active volcanoes. Plot the various locations on a map. Make a graph of volcanic eruptions during a given ten year period. Encyclopedias contain such information, as do many trade books and online computer services. Students may also look for information about the devastation caused by recent volcanic eruptions.

Family Involvement

Families might enjoy simulating the lava which flows from a volcano. Fill a 20 oz. soda bottle, or a glass fruit drink bottle about half full of vinegar. Add some red food coloring. Place the bottle in a pan or sink, and add about one teaspoon of baking soda. The resulting lava is harmless, but messy. Note: Under no conditions put a cap on this mixture (a MacGyver bomb, named after a character on the MacGyver television show who made home-made bombs).

Christian Application

It is hard for mankind to imagine and understand the immense power of a volcano. Nothing we can do will control a volcano or even predict its activity. Since God created the Earth and along with it all of the geologic phenomena we observe, volcanic activity is but a demonstration of that attribute of God which we call omnipotence. He is in control of all creation.

Extension

Create a diorama which shows a cross section of a volcano and the pools of lava beneath. Label the diorama to show the cone, dikes, magma pool, neck, and lava flows. Some students might wish to include batholiths, sills, and laccoliths in the cross section. Find out about the "ring of fire," which is a pattern of volcanoes on the rim of the Pacific Ocean.

References

Liem, Tik L. *Invitations to Science Inquiry*. Lexington, MA: Ginn Custom Publishing, 1981.
Namowitz, Samuel N. *Earth Science*. Lexington, MA.: D. C. Heath and Co., 1989.
UNESCO. *700* Science *Experiments for Everyone*. Garden City, NY: Doubleday & Co., 1958.
Lane, Frank W. *The Elements Rage*. Philadelphia: Chilton Books, 1965, pages 235-267.

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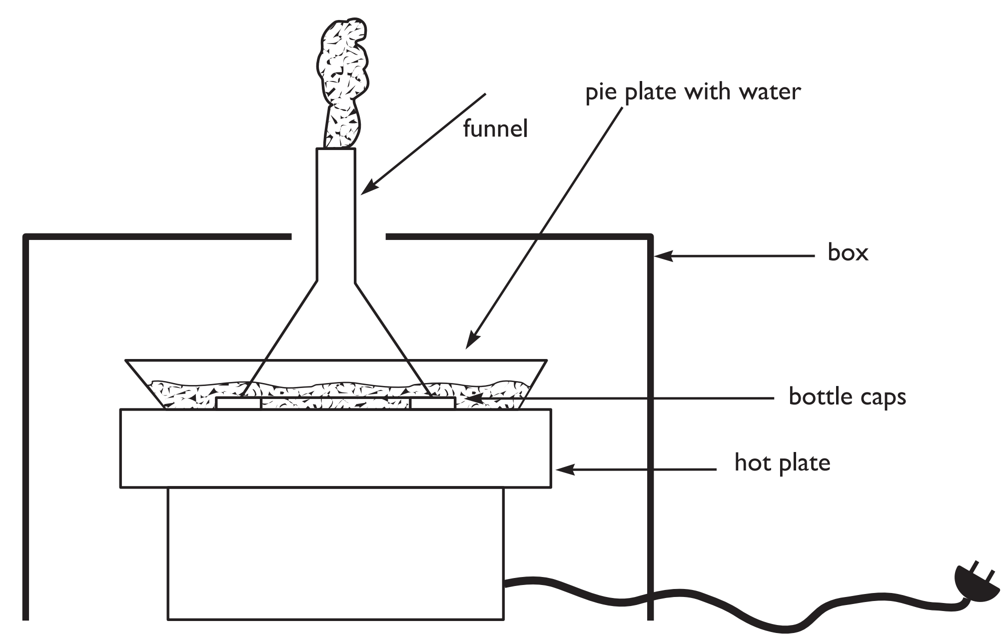
How does a volcano work?



31. Toys in Space

Equipment Needed

Video tape player and TV, pop-over mouse (or other pop-over toy), yo-yo, Wheelo flight model, metal top, slinky, gyroscope, magnetic marbles, wind-up car, jacks, paddleball, paper airplane

Purpose

To demonstrate how toys work differently in microgravity than they do on Earth

Safety—Special Considerations

Video tapes used in this lesson are available at any NASA Teacher Resource Center or contact

NASA CORE
Lorain County Joint Vocational School
15181 Route 58 South
Oberlin, OH 44074
Phone 216 774-1051, ext 293/294

Regional Teacher Resource Centers are located at many universities including University of Northern Iowa, Parks College of St. Louis University, Central Michigan University, Northern Michigan University, Oakland University, Mankato State University, St. Cloud State University, University of Nebraska State Museum, University of New Mexico, University of North Dakota, Oklahoma State University, University of Washington, and University of Wisconsin at LaCrosse.

Grade Level—Time Needed

Intermediate and upper grades; Time: One or more class periods

Background

On April 12, 1985, the space shuttle Discovery carried 11 familiar toys into the microgravity environment of space. With the toys aboard, the middeck became a space classroom and the astronauts were able to teach the nation's school children about the reaction of motion toys in zero gravity.

Procedure

Give a toy to each participant or group. Let each group experiment with the motion of the toy. Have them write or tell how each toy works on Earth. Then show the videotape *Mission 51-D Highlights* to demonstrate how objects behave in microgravity. Allow the students to predict how the toys will behave in space. Show the video *Toys in Space*.

Assignment

Bring a toy from home and be ready to talk about how it would work in space.

Christian Application

Discuss why we are thankful that God created gravity. Think of daily activities that would be difficult without gravity. Tell the students how astronauts lose bone mass when in space for extended periods of time. Our God created everything that we need to live.

Extension

Ask someone in class to write a prayer for the next day, thanking God for his creation of gravity and the blessings of gravity in our lives. If a space shuttle is currently in space or soon to launch, ask that the Lord would protect these people as they study this part of God's universe.

References

Idea taken from *Space Shuttle Activities-NASA*. All NASA materials are in the public domain and can be copied.

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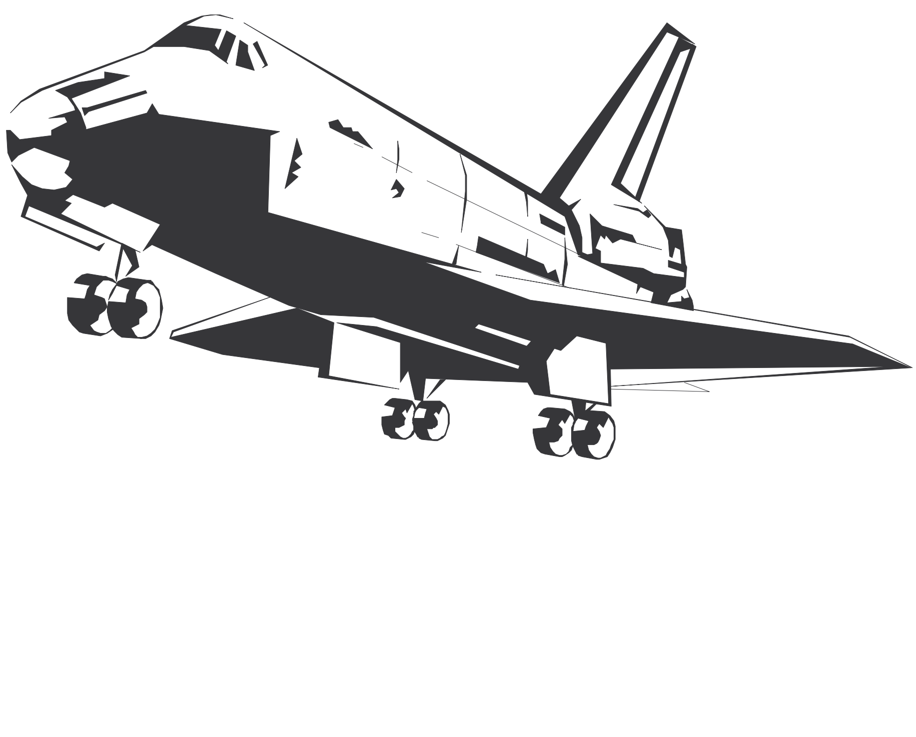

32. Size of the Sun

Equipment Needed

Basketball, grain of sand, meter stick

Purpose

To show how large the Sun is compared to Earth

Safety—Special Considerations

In order not to lose the sand grain, you could tape it to an index card.

Grade Level—Time Needed

Primary to intermediate grades; Time: 10-20 minutes

Background

The Earth is approximately 93 million miles from the Sun and one million Earths could fit inside the Sun. The Sun's diameter is 102 times the size of Earth's diameter.

Procedure

Set a basketball in the center of the room. Set a grain of sand approximately 3.5 meters from the basketball. This will demonstrate both size and distance of the Sun and Earth. Pluto would need to be 100 meters from the center. Have the children compare these distances to a football field. If the Sun were on one goal line, where would Earth and Pluto be? (five yard line and other goal line approximately)

Assignment

Use an encyclopedia to determine distance of two planets and the closest star, Alpha Centauri, in terms of benchmarks like the front door, or a football field or far-away towns.

Christian Application

Our God is an awesome God. Though millions of miles from the Sun, Earth is exactly in the right place to continue its orbit. This distance is also the correct distance so that life is possible, the Sun's heat being neither too cold nor too hot. All of this was God's plan at Creation. God has given us the mental abilities to discover planets like Pluto that are billions of miles from the Sun. In this tremendously huge universe, God, who is larger than his creation, still sees and loves each tiny soul. Read Psalm 8.

Extension

Go to a football field and set the basketball on the goal line, the sand on an index card on the five yard line and another grain of sand on the other goal line to represent Pluto. Try to find other spheres of relative size and place them in position to represent the other planets.

References

Tolman, Marvin N. and James O. Morton. *Earth Science Activities for Grades 2-8*. Science Curriculum Activities Library, West Nyack, New York: Parker Publishing, 1986.

JP

33. Moon Craters

Equipment Needed

Large pan, plastic dishpan or cardboard box, enough baking flour to cover the pan bottom with about three inches of flour, cocoa powder, three different sized rocks or stones (less than an inch, about an inch and more than an inch in diameter), newspaper, a spoon, and a centimeter ruler

Purpose

To determine how size and speed of meteors affect size of craters

Safety—Special Considerations

Weather permitting, this could be an outdoor activity.

Grade Level—Time Needed

Intermediate grades; Time: 30 minutes

Background

When an object falls, its speed increases as long as it falls. The higher above the surface of the earth the rock is, the more speed it will have at the time of impact. Craters are seen on the Moon but also on Earth as in the Barringer crater in Arizona. All solid planets and natural satellites in the solar system have craters on their surfaces. Terms related to this activity are the following: Crater basin—the crater impression; rim—the crater edge; and rays—the streaks radiating from the crater.

Procedure

Cover the bottom of the pan with flour to a level of about three inches. Sprinkle cocoa powder over the flour surface. Place several sheets of newspaper, overlapping each other slightly, in the area of the demonstration. Place the pan on the newspaper to facilitate cleanup. Before carrying out the activity, discuss what meteors are and their activity in space. Ask what we notice about the surface of the Moon that is different from Earth's surface. (You're looking for the answer "Craters.") Tell the students that this experiment will demonstrate how speed and size of meteors affect the size of impact craters formed on the moon. Ask for hypotheses as to what will happen when different size rocks are dropped from the same height. Record predictions. Drop (do not throw) the rocks from the same height and measure/record the size of craters formed. Discuss the results. Jiggle the pan to even out the flour and, if necessary, sprinkle on more cocoa. (If time allows, perform each part of the experiment three times and average the results.) For the second part of the experiment use just one rock and drop it from four different heights above the surface. Measure crater sizes formed and record results. Discuss how speed affects size of crater formation.

Assignment

Write a paragraph explaining the results of the activity, including what we can conclude about the energy of falling objects when both rock size and fall heights are combined.

Christian Application

Discuss who created the Moon, when it was created, and for what purpose. Refer to Genesis 1. Discuss why meteor craters are seldom formed on Earth. (When God created the earth, he created it with surrounding atmosphere which causes many of the smaller meteors to burn up before they reach the surface of the Earth. If they don't burn up they are called meteorites. God is protecting us with this blanket of air.) There also seems to be very few large meteors in the vicinity of the Earth's orbit that would be capable of making a crater.

Extension

In art class use tempera on black paper to paint a moonscape with craters. Find the Moon map available in encyclopedias and astronomy books to help visualize the image.

References

LHS Gems: Moons of Jupiter. Great Explorations in Math and Science, Lawrence Hall of Science, University of California at Berkeley, 1993.

JP

Worksheet

Moon Craters

Different Size Rocks Activity

Hypothesis:

	Drop 1	Drop 2	Drop 3
Rock 1			
Rock 2			
Rock 3			

Conclusion:

Hypothesis:

	Drop 1	Drop 2
1st height		
2nd height		
3rd height		

Conclusion:

34. A Three-Dimensional Magnetic Field

Equipment Needed

Clear plastic or glass container (16 oz. clear pop bottle, baby food jars), salad oil or corn oil, steel wool or iron filings, one or two stronger permanent magnets

Two magnets work the best. If used as a classroom project a magnet is not needed for each student.

Purpose

To demonstrate the magnetic field lines in three dimensions

Safety—Special Considerations

Normal lab safety procedures should be followed. Take care when handling the steel wool so the slivers of wool do not get stuck in your hands (do not rub your eyes). A funnel should be used when pouring the oil into the pop bottles. Baby food jars would be the best for a whole class project because each one holds less oil. Warn students to keep magnets away from computer disks.

Grade Level—Time Needed

Middle grades; Time: 20 minutes

Background

A magnetic field is a concept scientists use to understand how magnetic force behaves. The Earth, just like a magnet, is surrounded by a magnetic field. We need a demonstration like this to visualize what we think a field looks like.

Procedure

Take a pillow of steel wool and pull it apart. Now rub it together over a piece of paper. Small strands of steel wool will fall to the paper. When an accumulation of wool is seen on the paper, gather it up and place it into a jar. Repeat this step one more time. There should now be enough steel wool in the jar. Once there is sufficient material in the container fill the jar almost to the top with the vegetable oil. Cap the container tightly. Mix the material by shaking vigorously. Move a magnet to the container wall and observe what happens to the steel wool. Try different locations around the outside of the container as well as different arrangements of the magnetic poles. Shake the jar several times and record what happens to the magnetic field.

Clean up process: If used as a demonstration the jar may be saved for the next year. The students may even take them home if they wish. Steel wool fibers may either be disposed of or saved also for the next year.

Assignment

Put the magnet next to the jar as is shown (see diagram on following page). Sketch your results on the worksheet.

Family Involvement

If students make their own jar with oil and steel wool, they may amaze their parents and friends at home.

Christian Application

Aren't we all like the bits and pieces of steel wool? Without the magnet the tiny fragments of steel wool sit still. Without the Lord and his Word we also cannot do anything. Similar to the pieces of steel wool near a magnet, Jesus attracts us to himself. (Philippians 4:13)

Extension

This procedure is an opportunity to demonstrate the three-dimensional nature of the magnetic field. A two-dimensional field may also be demonstrated by placing a magnet under a piece of paper and sprinkling steel wool fibers or iron filings on it. See also "The Biggest Magnet of All: Earth" (Lesson 26).

References

Graf, Rudolf F. S*afe and Simple Electrical Experiments, #43*. New York: Dover, 1964.

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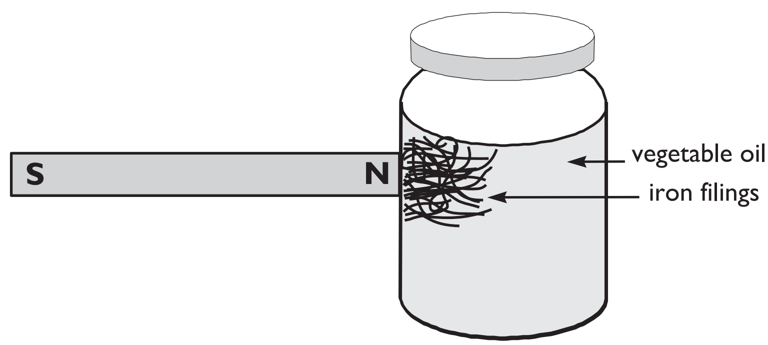
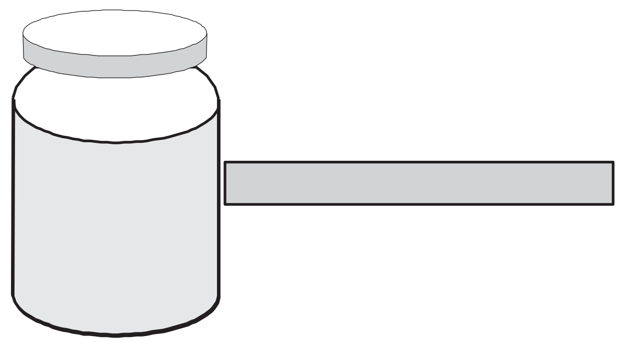
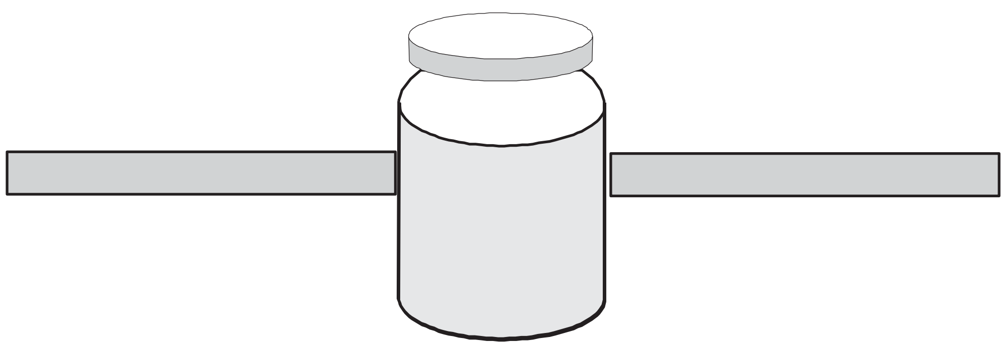
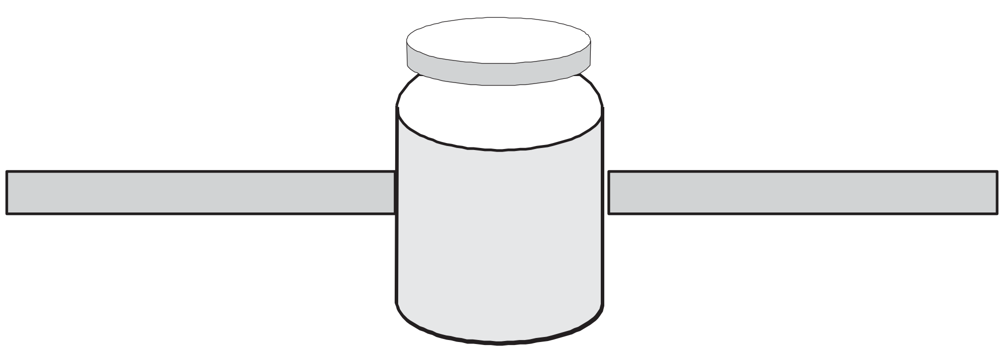


Worksheet #1

Draw what you see under each different situation. Be sure to label the North and South poles on the magnets.







35. Magnetic Repulsion and Attraction

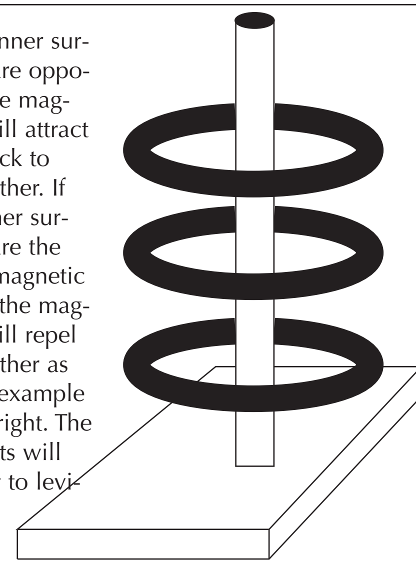
Equipment Needed

Two or more donut-shaped magnets available from electronic stores such as Radio Shack (the more the better), dowel (pencil will work), wood block with a hole in it to support the dowel (Clay or play putty can also be used to hold the pencil or dowel, or the students may just hold the pencil or dowel in their hands.)

Purpose

To demonstrate how magnets attract or repel each other

If the inner surfaces are opposite, the magnets will attract and stick to each other. If the inner surfaces are the same magnetic poles, the magnets will repel each other as in the example at the right. The magnets will appear to levitate.



Safety—Special Considerations

Caution should be taken if the pencils are sharpened and the children should not eat the clay or play putty. Keep magnets away from computer disks

Grade Level—Time Needed

Any grade

Background

Magnetic forces can be demonstrated on the table top by moving one magnet toward the other. If opposite poles are closer to each other the magnets will attract. If similar poles are closer to each other the magnets will repel.

Procedure

Place the dowel in the wood stand, clay, or just hold the pencil or dowel. Then place the magnets over the pencil or dowel. Observe. Flip the magnets over. Does anything change? Flip some of the magnets over again. Observe. What happens when you add more magnets?

Assignment

Write a report describing your observations. Draw diagrams to illustrate what happened with the magnets in the various positions.

Christian Application

Magnetism is a gift from God. The Lord has enabled us to find uses for this phenomenon. All generators and motors make use of magnetic repulsion and attraction. Magnetism is used to store data on computer disks. These devices have affected all our lives in some way or another.

Extension

On the table top the children may have magnet races. By lining up the similar poles toward each other the student can chase the other magnet around the desk.

Family Involvement

Make a list of items and appliances in your home that make use of magnets. Be sure to include how the magnets are used.

AP

36. The Rate of Chemical Reactions

Equipment Needed

Six Alka-Seltzer™ tablets, thermometer, three clear plastic cups, water, ice cubes, stop watch, masking tape to label cups

Purpose

To demonstrate how heat affects chemical reactions

Safety—Special Considerations

The children should be reminded not to drink the substance. The hot water should not be heated to temperatures higher than 50°C in case it is spilled on a student.

Grade Level—Time Needed

Intermediate and upper grades; Time: 20 minutes

Background

Chemical reactions occur when different substances, because of their molecular structure, produce a chemical change as they come into contact. Four variables affect the speed of the reaction: temperature, surface area, concentration, and use of catalysts.

Procedure

Label the cups A, B, and C. Fill cup A with ice water. Remove the ice after five minutes. Fill cup B with room temperature water, about 21 degrees Celsius. Fill cup C with hot tap water (40-50 degrees Celsius). Measure the temperature in each glass. Record all information in the table. Have the students predict in which cup the tablet will dissolve fastest. Record predictions. Drop one Alka-Seltzer™ tablet in each glass. Observe and record the amount of time it takes for the tablet in each cup to completely dissolve. Repeat the experiment and record the data again.

Now find the average time and record that. Discuss the results in comparison to the predictions. Form a conclusion and discuss the scientific process, especially focusing on the importance of controlling variables. Share the background information with the students and challenge them to think of another experiment using the same materials but changing a different factor (the student could partially crush the tablet to change the surface area, have differing amounts of water to change the concentration or could add some vinegar to the water to change the chemical environment.)

Assignment

Ask the students to conduct the experiment at home with parent supervision. Change the variable of surface area by crushing the tablet for one cup, breaking the tablet for another cup, and leaving it whole for the last cup. Make a prediction. Record the results by making a similar chart.

Christian Application

Our Lord is a God of order. His creation follows patterns and rules he has established. What is observed in science is orderly, and we can expect matter to act in predictable ways because of our orderly Creator.

Extension

Change the variable of concentration by using more water or more tablets in each cup. Have the students predict the results using their background knowledge from the first experiment. The original temperature-rate data can be graphed.

References

Science Experiments on File. New York: Facts on File, 1989.

JP

Alka-Seltzer is a registered trademark owned by Bayer Corporation.

Worksheet

Fast and Fizzy Reactions

	Variable Temperature	Prediction	Trial 1 Time	Trial 2 Time	Average Time
Cup A					
Cup B					
Cup C					

Conclusion

Select a different variable

	Variable Temperature	Prediction	Trial 1 Time	Trial 2 Time	Average Time
Cup A					
Cup B					
Cup C					

Conclusion

37. Heating Liquids

Equipment Needed

Flask or narrow-necked jar with one hole stopper or a cork with a hole drilled in the center (if using cork and the hole is not perfectly sealed with the tubing in, use wax or chewing gum to seal the hole), water, 30 cm of thin plastic tubing, food coloring

Purpose

To show how heat causes liquids to expand

Safety—Special Considerations

Place the jar in a safe place where it will not get bumped and broken. For speedier results, the jar could be set on a hot plate or in a bath of hot water and then later in ice water. Stop the heating when the water reaches the top of the tube; do not allow boiling to occur.

Grade Level—Time Needed

Intermediate grades; Time: 20-30 minutes

Background

As the water is heated, it will expand and rise up the tube. Conversely, as the water cools, it will contract down the tube. Generally, heat causes solids, liquids, and gases to expand. There are a few interesting exceptions; one is water. Water acts as expected at temperatures above 4°C. As the temperature falls below 4°, water does the opposite and expands. Therefore ice floats because it is less dense than liquid.

Procedure

Fill the jar to the rim with cold water and add several drops of food coloring to make it easier to see the movement of the water. Insert the tubing through the hole in the stopper and seal the hole with wax or gum if there is any space around the tube. The plastic tubing can be taped to a support. If glass tubing is used, follow safety guidelines on page xxii. Seal the narrow-necked jar with the stopper. Be sure there is no air space between the stopper and the water and the water should come partway up the tube to be visible above the stopper. Place the jar in sunlight or under a heat lamp. Observe the level of the water in the tube every few minutes, noting how the heated water rises up the tube. Place a white card or paper behind the tubing to make the water level more visible. If time allows remove the jar from the heat source and observe how the water contracts back down the tube. Discuss how this knowledge would help one to make a thermometer.

Assignment

Challenge the interested students to find a way to calibrate the set-up so that it would act as a thermometer.

Christian Application

God has blessed us with the ability to create thermometers to measure temperature, which allows us to learn many things about our environment. If we didn't know about specific temperatures, we couldn't make certain candies, like peanut brittle that mothers make at Christmas time.

Extension

Students could research the history of the Fahrenheit and Celsius thermometers. This activity relates well with Heating Gases (lesson 40) and Heating Solids (lesson 44).

References

Tolman, Marvin N. and James O. Morton. *Physical Science activities for Grades 2-8. Science Curriculum Activities Library.* West Nyack, New York: Parker Publishing, 1986.

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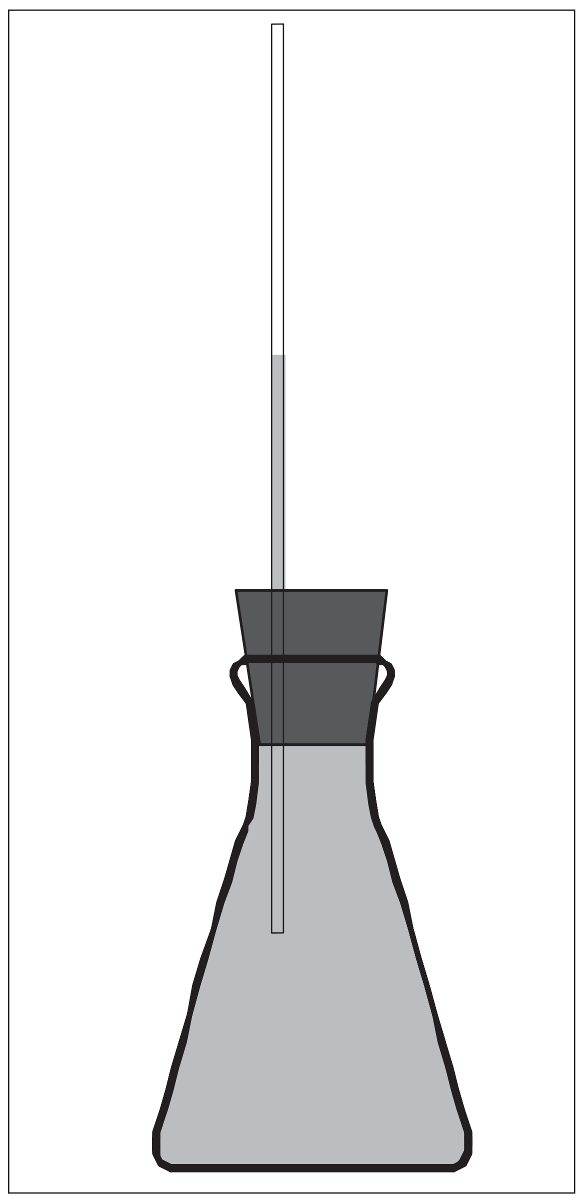

38. Heat Convection in Liquid

Equipment Needed

Two baby food jars that are the same size and have smooth rims without nicks, food coloring, an index card, a means of heating water, a pie pan or tray for use as an overflow container

Purpose

To demonstrate how heated fluids convect upward

Safety—Special Considerations

The teacher should have the water heated almost to boiling and have a safe method for pouring the water into the jars. Try this in advance to test if the baby food jar will break when hot water is poured into it. **This is a teacher demonstration only.**

Grade Level—Time Needed

Upper primary or intermediate grades; Time: 20-30 minutes

Background

Warm water is less dense than cold water. Therefore warm water rises as the cooler, denser water settles below. This is a convection current of fluids. Air is also a fluid and shows convection.

Procedure

Set the jars in the pie pan or tray. Fill one jar just to the rim with cold tap water and the other with near boiling water. Put several drops of food coloring in the cold water so that it will be a different color from the hot. (You could also color the hot water a different color.) Place the index card over the cold jar leaving no air space. Carefully invert the cold jar and place it directly on top of the hot jar. Ask the students what will happen if the water in the jars is allowed to mix. Remove the index card so that the jars now form a kind of hour glass. Observe what happens. Ask the students to draw a conclusion.

Assignment

Draw a diagram and write a paragraph describing what happened in the activity.

Christian Application

God's creation is predictable. Our Lord is the God of order. This is a comfort to us, knowing that the Lord himself does not change but is as he says he is and will do what he promises. (Ps 111:7-10)

Extension

Ask where water in a lake seems cooler when you go swimming. Repeat the experiment but put the hot water on the top (use hot pad or cooking mitts). Predict what will happen.

References

Marson, Ron. *TOPS Learning Systems:Heat #15. Learning Systems Task Card Series,* 10970 S. Mulino Rd., Canby OR 97013, 1987.

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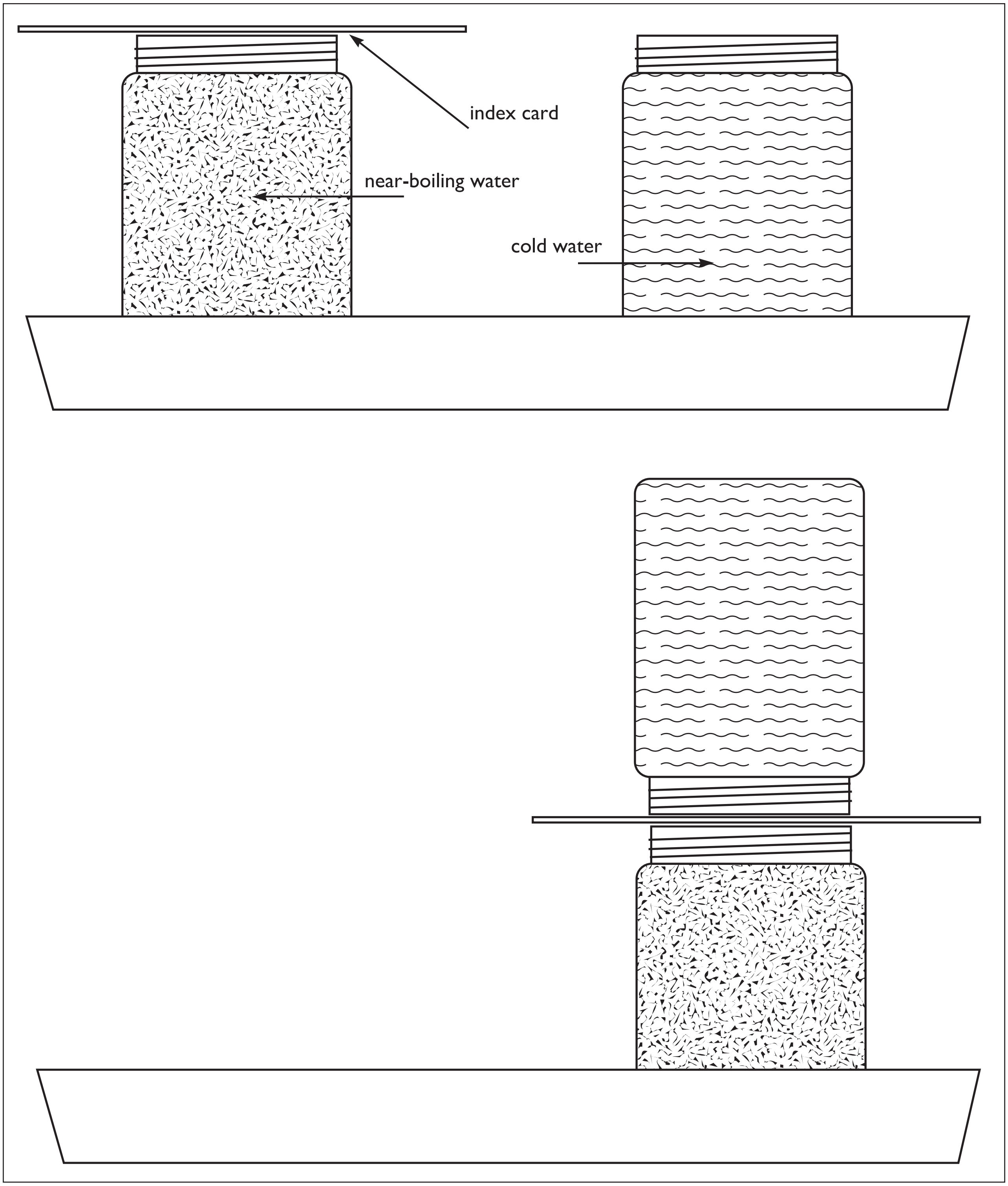

39. Heat Emitters

Equipment Needed

Three test tubes, aluminum foil, white paper, black paper, jar or beaker, two rubber bands, boiling water, spouted container, thermometer, tape

Purpose

To test different surfaces as heat emitters
To distinguish between conduction and radiation

Safety—Special Considerations

Measure the temperatures by inserting only the bulb of the thermometer into the water. Always check temperatures in order of which tube the water was poured in first. Use caution with the hot water and test tubes.

Grade Level—Time Needed

Intermediate and upper grades; Time: 30 minutes

Background

Thermal energy flows from hot matter to cold matter. Heat gain or loss due to contact is called conduction. Energy gain or loss without touching or contact is called radiation. Shiny surfaces reflect heat back into the water, keeping it warmer; therefore, aluminum is the worst heat emitter. Black absorbs heat best and radiates it to the outside. White reflects heat back into the water somewhat but not so well as aluminum. The glass in the test tube is a good conductor. Air is a poor conductor. Aluminum is a good conductor, but paper is a relatively poor conductor. The results may be ambiguous because both radiation and conduction may be occurring.

Procedure

Cover each test tube tightly with either aluminum foil, white paper or black paper. Use tape to hold the material in place around the tube. Use the two rubber bands stretched over the mouth of the jar or container forming an X over the opening to hold the three tubes separately. Fill each test tube with hot water and record the temperatures. Ask the students to predict which tube will emit heat faster. Record prediction. After five minutes record temperatures again. Do this three times in five minute intervals. Determine which type of covering emits heat more quickly. Record conclusions.

Assignment

Fill out the worksheet. In the conclusion use the words conduction and radiation.

Christian Application

By understanding the order that God has put into this part of the Creation, we are able to control situations in which we need to keep things warm or cool. This is a great blessing.

Extension

This activity relates well to Heat Absorbers (lesson 42). Ask why the inside of thermos bottles are often shiny.

References

Marson, Ron. *TOPS Learning Systems: Heat #15. Learning Systems Task Card Series,* 10970 S. Mulino Rd., Canby OR 97013, 1987.

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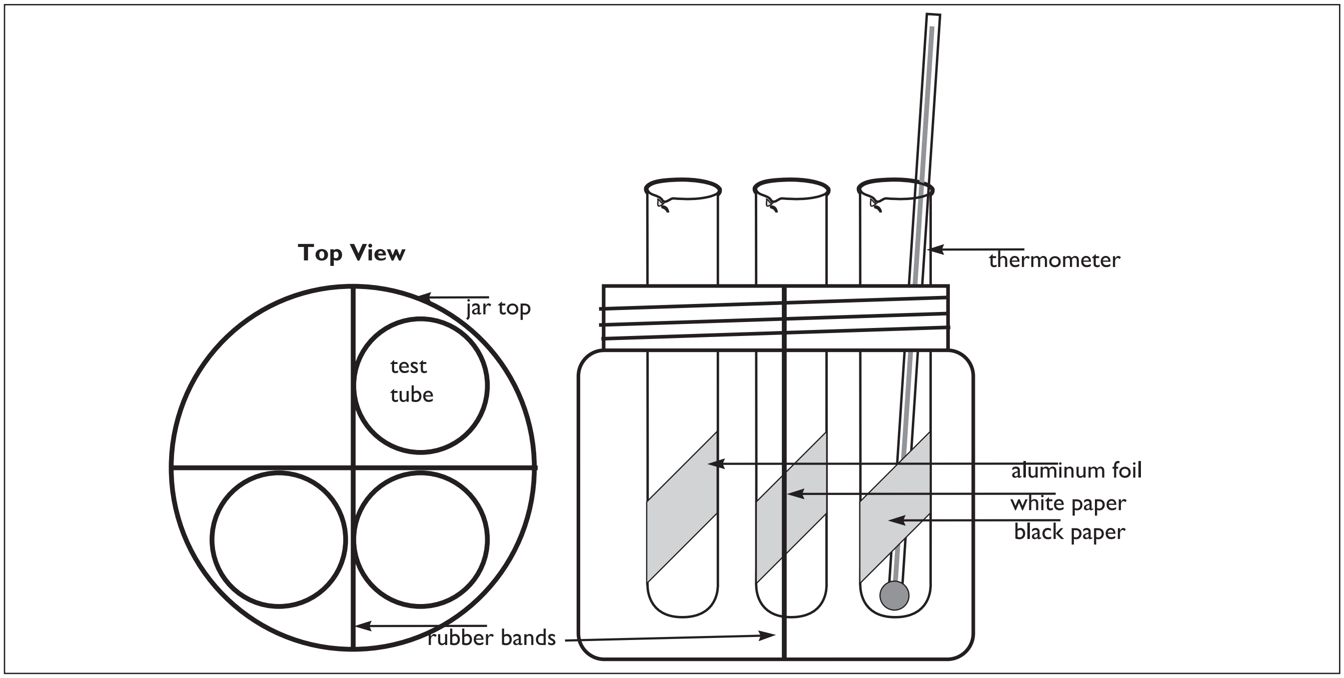


Worksheet

Heat Emitters

Purpose: to test different surfaces as heat emitters
to distinguish between conduction and radiation

	Starting Temperature	5-minute temp	10-minute temp	15-minute temp
Aluminum				
White				
Black				

Conclusion

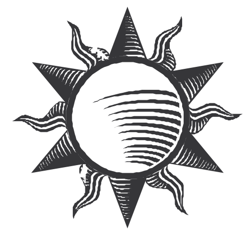
40. Heating Gases

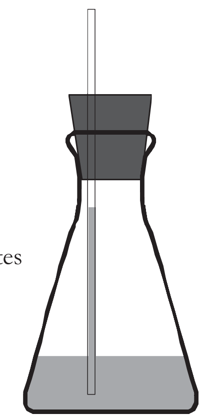
Equipment Needed

Flask and stopper or narrow-necked jar with stopper to completely close the opening, 30 cm of tubing to fit the hole in the stopper

Purpose

To show how heat causes gases to expand





Safety—Special Considerations

Remind the students to be cautious with glass.

Grade Level—Time Needed

Primary to intermediate grades; Time: 10-20 minutes

Background

Heat causes matter to expand. The air in the flask is heated and expands, putting more pressure on the water and forcing it up the tube.

Procedure

Put a little water in the bottom of the jar (about two or three cm). Insert the tubing into the hole in the stopper. Use the stopper to seal the flask. The tube must be inserted far enough to reach into the water. Note the level of the water in the tube. Place the jar in sunlight or under a heat lamp. Ask the students to predict what will happen to the water in the tube. Observe how the heated air causes the water to rise up the tube by checking its level every three minutes for one-half hour. Remove the jar from the heat source. Ask the students to predict what will happen to the water level in the tube.

Assignment

Bring thermometers from home and see if they all record the same room or outside temperature. Write a paragraph describing what happened in the activity.

Extension

This activity complements Heating Solids (lesson 44) and Heating Liquids (lesson 37).

Christian Application

Our God has done thhings that we can trust. He is consistent and faithful in all his ways (Ps 111).

References

Tolman, Marvin N. and James O. Morton. *Physical Science activities for Grades 2-8. Science Curriculum Activities Library*. West Nyack, New York: Parker Publishing, 1986.

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41. Heat Race

Equipment Needed

A 25 cm length of each kind of wire: copper, aluminum, iron; wax paper, three clothespins, newspaper, pie pan and candle, nine paper clips

Purpose

To test different metals as heat conductors

Safety—Special Considerations

Keep the wax from dripping into the flame because wax is combustible. Also keep the wax from dripping onto carpet, clothing, or people. Be very careful during the melting of the wax. Wax can be hot enough to cause severe burns.

Grade Level—Time Needed

Intermediate grades; Time: 30 minutes

Background

Different metals have different molecules packed together at different densities. Heat will conduct from particle to particle at different rates. Heat is energy.

Procedure

Lay out newspaper to cover a work area because wax may drip in this experiment. Put a wire and three paper clips on the wax paper beginning about 5 cm from the end of the wire and separate the clips by 2 cm. Place the paper clips so that one end just touches the wire. Drip melted candle wax onto the three paper clips where they touch the wire. Repeat the process for the other two wires.

Have the students predict which wire will conduct heat faster. Record predictions and discuss the scientific method of hypothesis and experimentation. Tie one end of all three wires together. Place the pie pan with its lighted candle in the center of the area. Clip the other end of each wire into a clothespin as a holder and have someone hold each of the three wires so that the junction is in the candle flame as shown in the diagram. Observe which wire begins to drop clips first, second, and third. Check predictions. If there is enough time, the experiment could be repeated to check the results. Students should conclude that different metals conduct heat at different rates.

Assignment

Challenge the students to bring a wire of different diameter or metal from home with paper clips attached similarly. Remind them that the clips should be attached starting five cm from the end and then two cm apart. Have a heat race among the class members. They will need to take care not to poke anyone with a wire.

Christian Application

Fire is often a symbol of God. Read Micah 1:2-4.

Extension

As a primary activity, just coat one wire with wax and observe the results of heating. Discuss transfer of heat from particle to particle along the wire. Extended activities could include the concept of diameter as a another variable.

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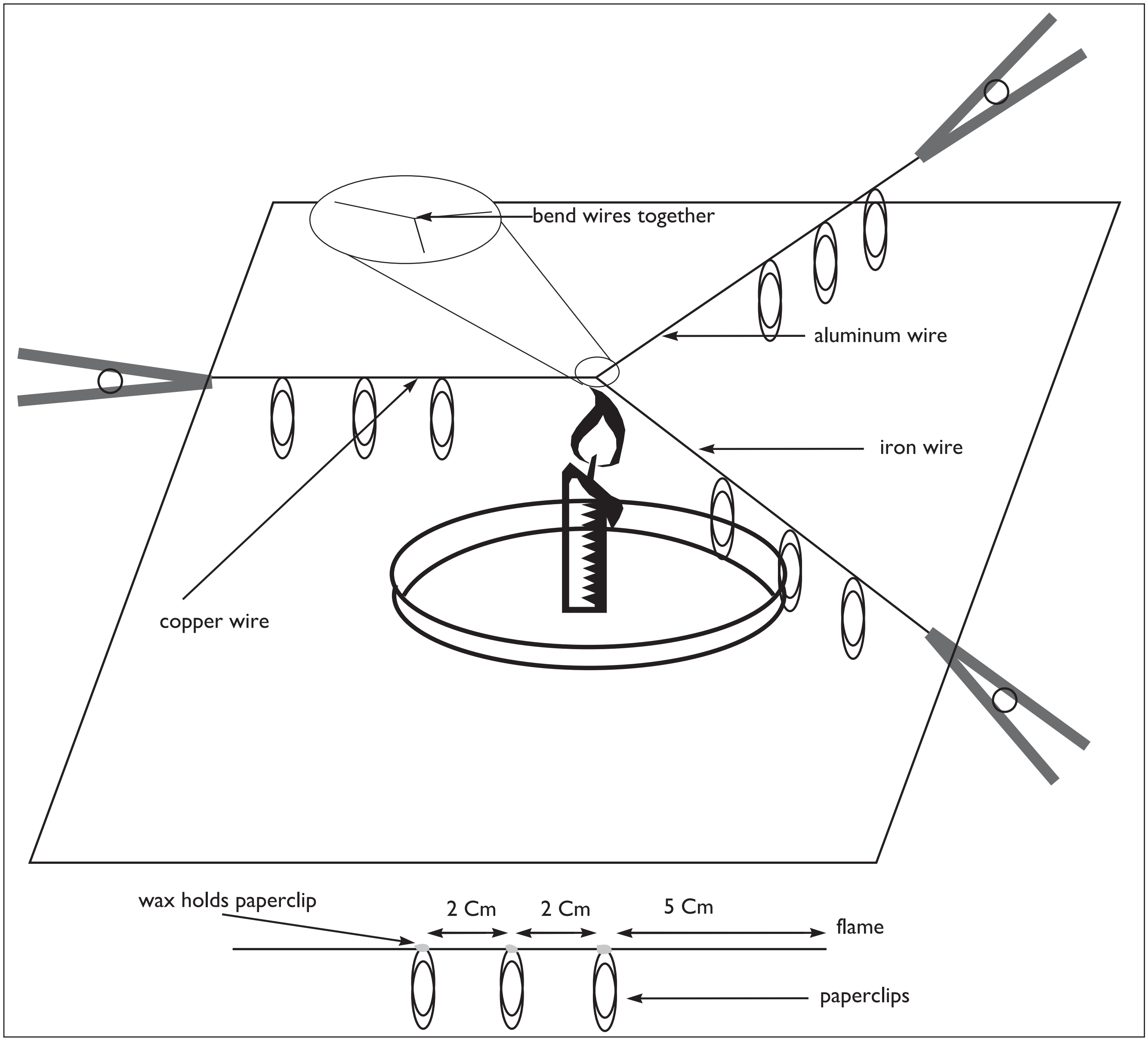


Prediction: ____________ first, ____________ second, ____________ third

Write a hypothesis statement ____

____

____

Results of experiment

Trail 1 ____________ first, ____________ second, ____________ third

Trial 2 ____________ first, ____________ second, ____________ third

Conclusions

____

____

____

42. Heat Absorbers

Equipment Needed

Three test tubes, aluminum foil, white paper, black paper, water, thermometer, three stoppers, tape, heat lamp or a desk or gooseneck lamp with a 75 watt or 100 watt bulb

Purpose

To test different surfaces as heat absorbers

Safety—Special Considerations

If there is not a lamp available, you will need a sunny spot to do this experiment. Measure the temperatures by inserting only the bulb of the thermometer into the water. Always check temperatures in the same order.

Grade Level—Time Needed

Primary to intermediate grades; Time: 20-30 minutes

Background

Shiny surfaces reflect heat best; therefore aluminum is the worst heat absorber. Black absorbs heat better than white and radiates it to the inside and so black is a good heat absorber. White reflects heat but not as much as aluminum.

Procedure

Cover three test tubes with aluminum foil, white paper, and black paper, using a small amount of tape if necessary to keep the material in contact with the test tube. Fill each with room temperature water and close with stoppers. Set all three in direct sunlight or in the light of a heat lamp. Have the students predict which tube will absorb the heat faster. Record predictions and discuss the scientific method of hypothesis and experimentation. After at least ten minutes use the thermometer to measure the temperature of each tube. Check your predictions.

Assignment

Fill out the worksheet. Use the words reflect and absorb in the conclusion.

Christian Application

Ask the children to think abstractly. *What should Christians reflect to others?* (The love of Jesus.) *What should Christians absorb?* (The Word of God.) *Using the Word as our aluminum shield, what will bounce away from us?* (the temptations of Satan.)

Extension

This experiment complements the lesson, Heat Emitters (lesson 39).

References

Marson, Ron. *TOPS Learning Systems:Heat #15. Learning Systems Task Card Series,* 10970 S. Mulino Rd., Canby OR 97013, 1987.

JP

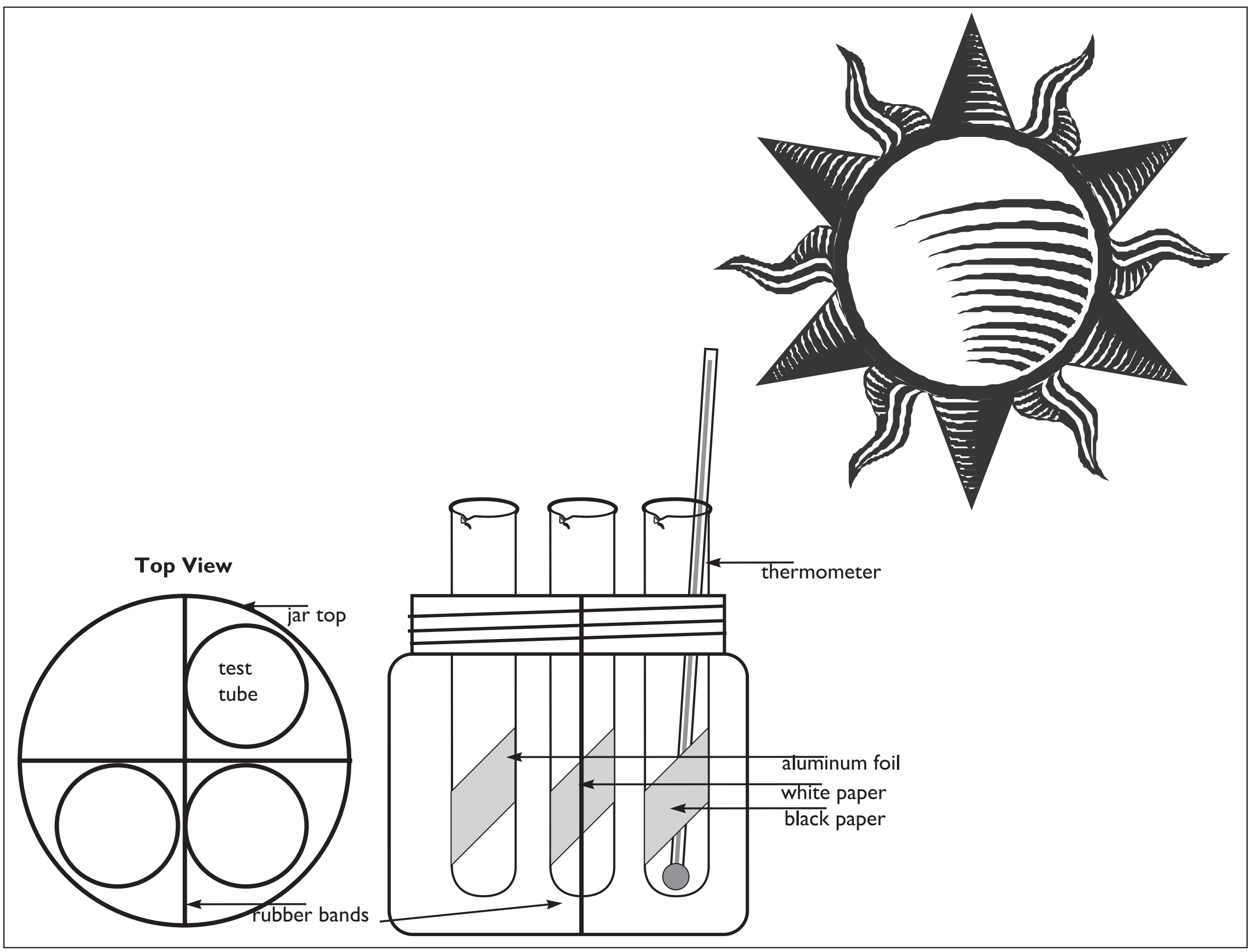
Worksheet

Heat Absorbers

Purpose: to test different surfaces as heat absorbers

	Material	Trail 1 (°C)	Trial 2 (°C)	Trail 3 (°C)
Cup a				
Cup b				
Cup c				

Conclusion



43. Heating Molecules

Equipment Needed

Masking tape

Purpose

To show how heat causes molecules to move faster and farther apart

Safety—Special Considerations

Remind the children to keep others in mind as they move and not hurt anyone as they "pretend" to bump into each other.

Grade Level—Time Needed

Primary and intermediate grades; Time: 10 minutes

Background

As matter is heated the particles move more quickly. Moving particles begin to bump into each other, requiring more space. This is why most matter expands when heated.

Procedure

Use the masking tape to outline a circle large enough for all the students to stand comfortably inside. Direct the children to stand in the circle and move around slowly without pushing. This demonstrates the movement of particles in matter. Have the children move quickly and still remain inside the circle. This demonstrates the heating of molecules. Finally, have the students move very quickly causing some to be forced out of the circle. This demonstrates the changing state of matter from solids to liquids to gases when heated. The teacher can callout, "more heat," or "less heat." Calling out "freeze" would requite the students to pack into a solid.

Assignment

At home, with parental supervision, have the student stretch a balloon over a empty beverage bottle and set it in hot water. Have the child explain to the parents why the balloon expands. Boil the water and have the child explain why the water bubbles.

Christian Application

God has created everything to follow rules that we call the laws of nature. Our Lord is the God of order and we can expect matter in God's world to act in certain ways. It is also a comforting reminder to us to know that the Lord himself does not change but is as he says he is and will do what he promises. (Read Psalm 136.)

Extension

Ask the children to brainstorm about activities in the congregation that would excite them. Remind them that, just as in matter, when some get started, this will stimulate others. Choose one of the student's ideas and start to work on it as a group, watching to see how others join.

References

Tolman, Marvin N. and James O. Morton. *Physical Science Activities for Grades 2-8. Science Curriculum Activities Library.* West Nyack, New York: Parker Publishing, 1986, p. 50.

JP

44. Heating Solids

Equipment Needed

One meter of thin wire, a large nail or bolt, candle, matches, newspaper

Purpose

To show how heat causes solids to expand

Safety—Special Considerations

Choose a responsible student to hold the burning candle to the wire.

Grade Level—Time Needed

Intermediate grades; Time: 20 minutes

Background

Heat causes the particles in a solid to move faster and spread apart or expand the solid. When solids are cooled the particles slow down causing the solid to contract.

Procedure

Tape a meter stick to a chair as shown in the diagram. Wrap the wire around the nail and suspend it above a table from the meter stick so that it swings freely but is very near to touching the surface. Set newspaper under the work area to catch any dripping wax. Ask the students to predict what will happen if the wire is heated. Light the candle and hold its flame against the wire above the nail. Observe what happens to the nail. (The nail should eventually touch the near surface.) Remove the flame and allow the wire to cool. Ask for a prediction while you wait. Observe the nail again. Ask what is the effect of heat on solids. Relate this to sidewalks and road surfaces in summer and winter. Ask why construction workers put lines in the concrete when making sidewalks. Ask if the children have ever noticed the strange toothed bands of metal running across bridge surfaces. These are called expansion joints. Ask how these are helpful. (Both aid in preventing break-up due to surface temperature changes.)

Assignment

Have the students write a paragraph explaining what happened. They should use the terms expansion and contraction in their explanation.

Christian Application

God has given us the knowledge to understand the effects of heating and cooling solids so that we can build good roads and bridges. When we think of our reasoning abilities we can say with David, "I will praise God for I am fearfully and wonderfully made." Humans have built many good roads with this knowledge, allowing us to travel to many places.

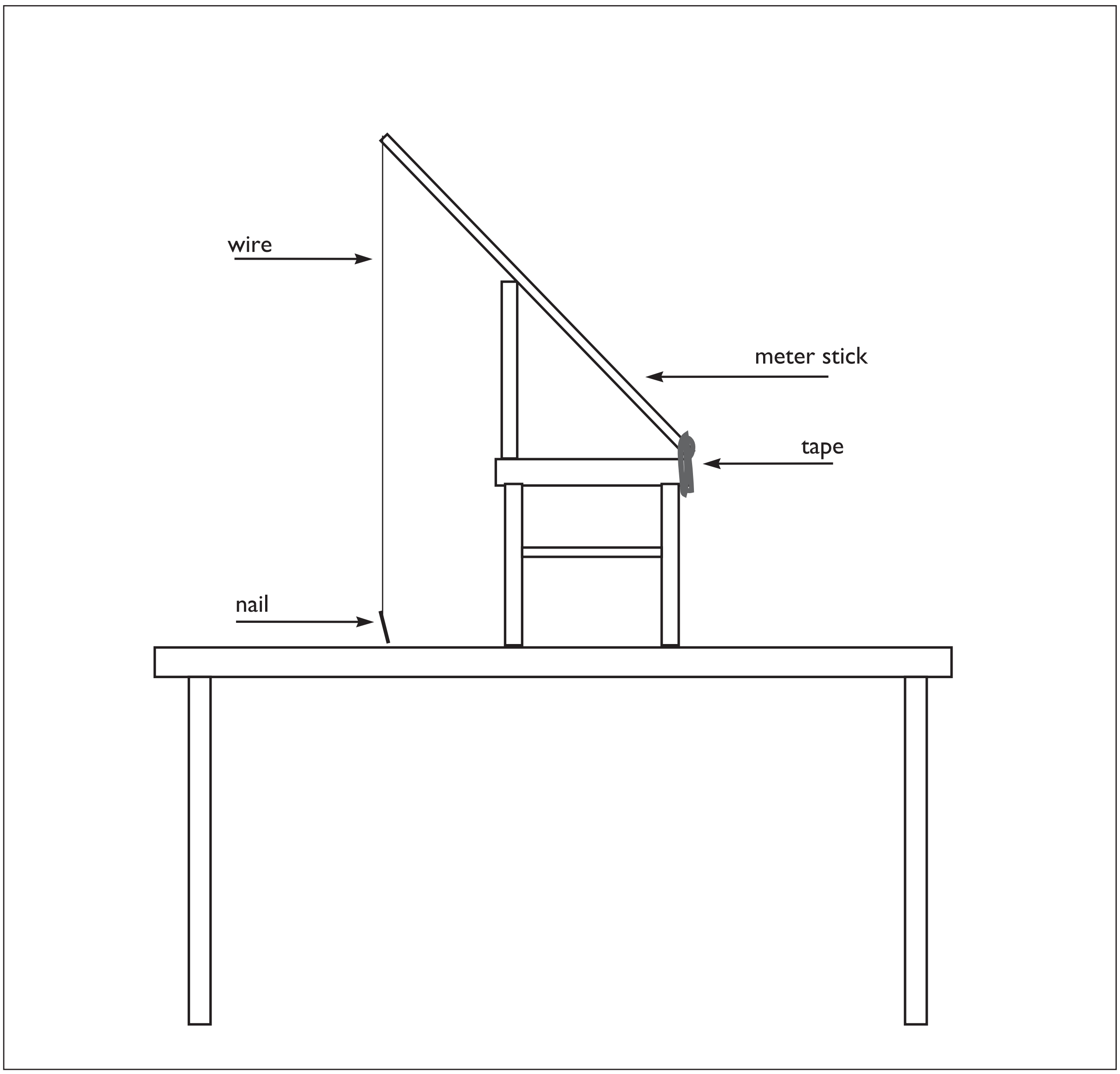
Extension

Ask why people put jar lids under hot water if they cannot open the jar. The metal is heated and expands, loosening the lid. Ask why people put their hands in cold water when they can't get a ring off. The hand will cool, change blood flow and shrink slightly allowing for the removal of the ring. Try both activities if possible.

References

Tolman, Marvin N. and James O. Morton. *Physical Science Activities for Grades 2-8. Science Curriculum Activities Library.* West Nyack, New York: Parker Publishing, 1986, p. 51.

JP



45. Convection Machine

Equipment Needed

Scissors, index card, needle, at least 12” of fine thread, tape, candle, and matches

Purpose

To show how heat is convected through the air

Safety—Special Considerations

Remind the children to be careful with the matches and candle. It might be good to put the candle in a pie pan for added safety. Keep the paper coil about one hand span from the top of the flame or it may catch afire.

Grade Level—Time Needed

Intermediate (or primary if the teacher is demonstrating with the candle) grades; Time: 10 -15 minutes

Background

Convection currents form when air is heated. The warm air rises and cooler air replaces it. As the heated air cools again, it moves down as more warm air is rising.

Procedure

Cut out the coil from an index card. Using the needle, insert the thread through the dot in the center, and knot the end to keep the thread attached to the coil. Place a small piece of tape over the knot to keep it from pulling out. Pull on the spiral to stretch it out a bit. Light the candle and hold the coil at least a hand span above the flame. Watch what happens. The coil should begin to spin. A convection current is flowing. Note the direction of spin. Put the coil near a cold window or wall where cool air could be descending. Note the direction of spin.

Assignment

Take the coil home and hold it in different places to see if convection currents are formed for heating systems or cool windows in the home.

Christian Application

Heat is the energy that moves the coil. Remind the students that something also motivates the human soul. Christians want to be moved by the love of Christ and stay away from the false energy of the world and its temptation which move many souls to foolish and hurtful situations. The students could write these words around their coils: Jesus’ love warms our hearts and moves us to acts of kindness.

Extension

Hang the children's coils from different places around the classroom ceiling to watch how currents form when the heating system turns on. Note if there are any areas in the room with lesser activity or a different direction. Ask why. Ask how this rule affects hot-air ballooning.

References

Tolman, Marvin N. and James O. Morton. *Earth Science Activities for Grades 2-8. Science Curriculum Activities Library*. West Nyack, New York: Parker Publishing, 1986, p. 43.

JP

46. Peanut Power

Equipment Needed

A peanut, a straight pin, tin can lid, masking tape, two pie pans, three baby food jars, 500 ml of water, matches

Purpose

To measure the calories in a peanut

Safety—Special Considerations

Be cautious when burning the peanut. Do this experiment on a safe surface. Save the packaging the peanut came in to use the Calorie information. Long fireplace matches might be easier to use.

Grade Level—Time Needed

Intermediate and upper grades; Time: 20-30 minutes

Background

We often use the term burning calories. This is in reference to the chemical changes that happen within the body in order for energy to be released in the cells. The fuel is stored in food. One calorie = a change of 1 °C per gram of water. The formula for calculating heat gained or lost is Heat (calories)= $\Delta T(°C)$ x mass of water(g). $\Delta T(°C)$ is the change in temperature of the water in degrees Celsius.

Procedure

Measure the mass of a half peanut on a balance scale. Make a holder by pushing the straight pin through a piece of masking tape starting on the sticky side. Tape the pin to the tin lid and mount the peanut on the pin. Use the three jars as a tripod to hold one inverted one pie pan and then place the other on top of the first pan. Find the mass of the water. If 500 ml are used, the mass will be 500 g. The water goes in the top pie pan and the mounted peanut goes under the tripod. Record the temperature of the water to tenths of degrees Celsius. Light the half peanut and when it is burning well, slide it under the tripod. Record the highest temperature the water reached again to the tenth of degrees. Find the mass of the charred peanut. Calculate the calories of heat per gram generated by the burned half peanut. Check on the package the peanut came in to learn calories per gram. One Calorie = 1000 calories.

Assignment

Have the students write a paragraph explaining what happened in the activity. Remind them that the topic of the paragraph should be the purpose of the experiment.

Christian Application

The energy we need has been stored in food by God's design. He has created our bodies so that, amazingly, we can release the calories in food to use in our bodies without the need of fire.

Extension

Discuss what happens when we take in more calories than we expend (the body stores it as fat). Also discuss how the body can break down tissue for energy when we are not taking in food.

References

Marson, Ron. TOPS Learning Systems: Heat #15. Learning Systems Task Card Series, 10970 S. Mulino Rd., Canby OR 97013, 1987.

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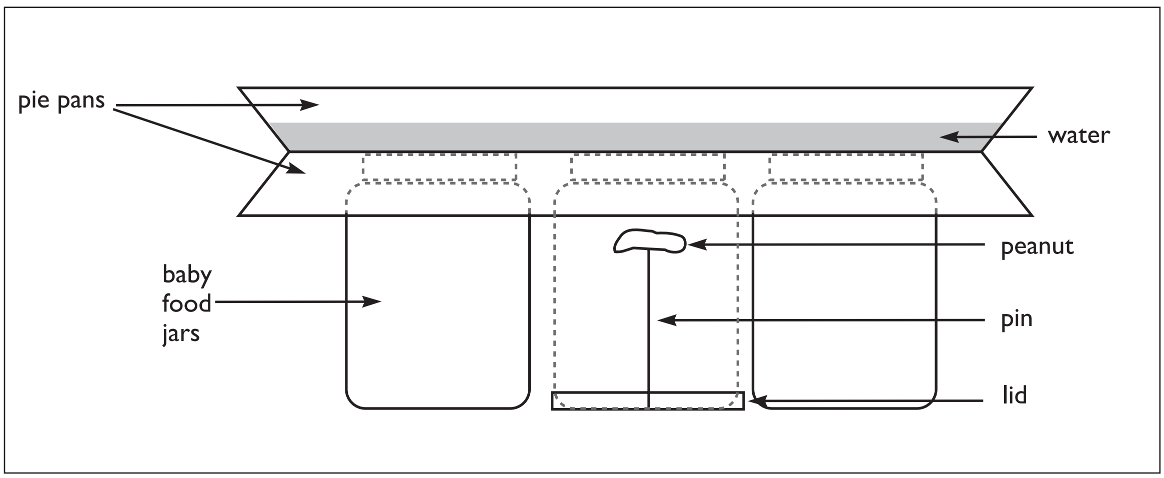

Mass of water: ___________ g

Mass of peanut: ___________ g

Ending temperature: ___________ °C

Beginning temperature: —__________ °C

Change in temperature (ΔT): ___________ °C

Heat = ΔT x mass of water

47. Unburnable Paper Cup

Equipment Needed

Paper cup, water, candle, short piece of wire, long pencil, clothes pin, small thermometer

Purpose

To show that a substance must reach its combustion (kindling tempeature) point before it will burn

Safety—Special Considerations

The paper cup should not ignite but the teacher should be careful choosing who will hold the cup over the flame. Setting the candle in a pie pan will provide more safety. The cup must be wax free if a bunsen burner is used.

Grade Level—Time Needed

Intermediate grades; Time: 20 minutes

Background

Burning does not happen until the material being heated reaches its combustion point. The water in the cup conducts the heat from the candle away from the paper, which does not allow the paper to reach its combustion point. The temperature of the paper-water system will be no higher than 212°F (100°C) as long as there is water in the cup. The combustion point of paper is 451°F.

Procedure

Form a handle with the wire by inserting it through two edges of the paper cup so that it looks like a little pail. Use the clothes pin to clamp the wire handled cup to the end of the pencil to keep the cup from sliding along the pencil. Fill the cup at least half full with water. Put the small thermometer into the cup and record its reading. Hold the cup over the flame of the candle. Ask the children to predict what will happen. Hold the cup in the flame for a few minutes demonstrating that the paper does not burn. Check the thermometer. Ask the students when the paper cup will burn (when the water has evaporated).

Assignment

Make a drawing of the experiment using arrows to show where heat is transferred.

Christian Application

Water has many properties that make it special in nature. If God had not thought to create water with unexpected properties, life would be impossible as we know it. Our God is very wise. His works are wonderful.

Extension

Some students will enjoy reading the science fiction classic, *Fahrenheit 451* by Ray Bradbury.

References

Bradbury, Ray. *Fahrenheit 451*. New York: Simon and Schuster, 1967.
Ehrlich, Robert. *Turning the World Inside out and 174 Other Simple Physics Demonstrations*. Princeton, NJ: Princeton University Press, 1990, pp. 118-119.

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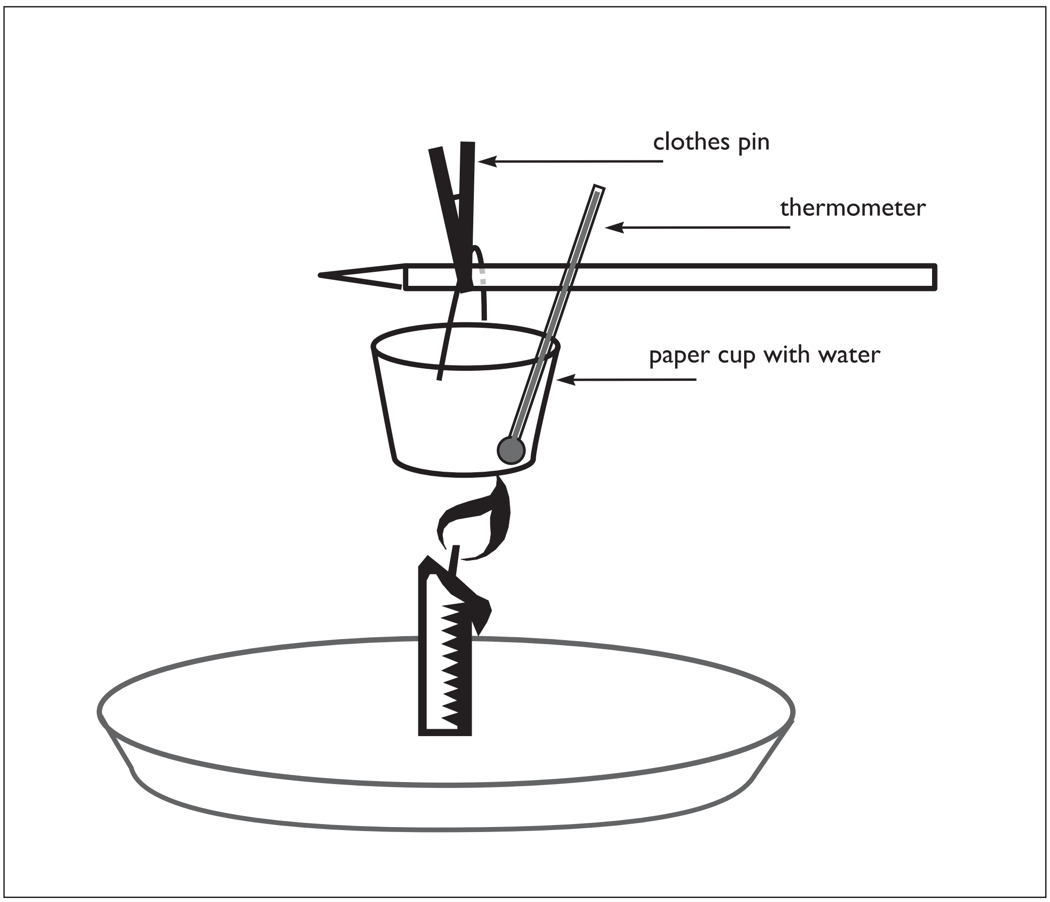

48. How Do Rockets Work?

Equipment Needed

A plastic baby bottle and a cork to stop it, baking soda (a thermos cork works), tissue paper, vinegar, Vaseline, six or more round pencils, and a board two feet long by six or more inches wide.

Purpose

To demonstrate Newton's Third Law of Motion using rocket thrust

Safety—Special Considerations

It might be best to conduct this experiment outdoors. Remind the students that this experiment should be conducted under adult supervision. The students should be off to the side, not to the front or the rear of the bottle. Make sure that the cork can slip out of the mouth easily and do not increase the amount of baking soda.

Grade Level—Time Needed

Intermediate grades; Time: 20-30 minutes

Background

Rockets can work in space. In a liquid fuel rocket, tanks of liquid fuel and liquid oxygen are pumped into the combustion chamber and ignited. The liquids then expand to gases and rapidly build pressure in the chamber. As the hot gases escape through the nozzle at the bottom of the rocket, a force is created in the opposite direction causing the rocket to shoot forward or up. The mass of the gas times its velocity equals the mass of the rocket times its velocity. The high velocity of the gas produces a momentum that allows movement of a very massive rocket.

Procedure

Lay the board on a flat surface with the pencils spread out to act as a series of rollers. Lubricate the cork and inside bottle neck with Vaseline. Fill the bottle to half with a mixture of 50% water and 50% vinegar (fuel). Put two teaspoons of baking soda (oxidizer) in a square of tissue paper and twist the ends to hold the soda in a sausage like containment. Slip the tissue into the bottle and put the cork in place. Position the bottle on its side on the pencils which are laid out parallel to each other and slightly separated as a run-way for the bottle rocket. Ask the students to predict what will happen. When the soda mixes with the vinegar, a chemical reaction takes place, which releases a large quantity of rapidly moving, expanding gases which will press against the cork and force it out. This force will create an opposite force on the bottle and push it across the pencils. Ask the students to state a rule of science about motion. (Newton's third law: For every action there is an opposite and equal reaction.)

Assignment

Students should write a paragraph explaining how rockets are launched into the atmosphere. Maybe someone could bring a video tape of a real NASA launch.

Christian Application

Building rockets can be an exciting idea for some youthful scientists. Remind the children of how precious we are to our heavenly Father, so much so that he wants us to take care of our bodies, not putting ourselves or others into a dangerous situation by playing with materials that cause strong chemical reactions. God wants us to use new knowledge responsibly.

Extension

Draw a picture of the space shuttle on the launch pad, launching, or in orbit. Label the parts: external fuel tank, solid rocket boosters, orbiter.

References

Williams, Debbie and Carol Hickson. *Space Exploration: Demonstration Aids for Aviation Education V.2.* developed by Civil Air Patrol Center for Aerospace Education Development, FAA, 20 pages.

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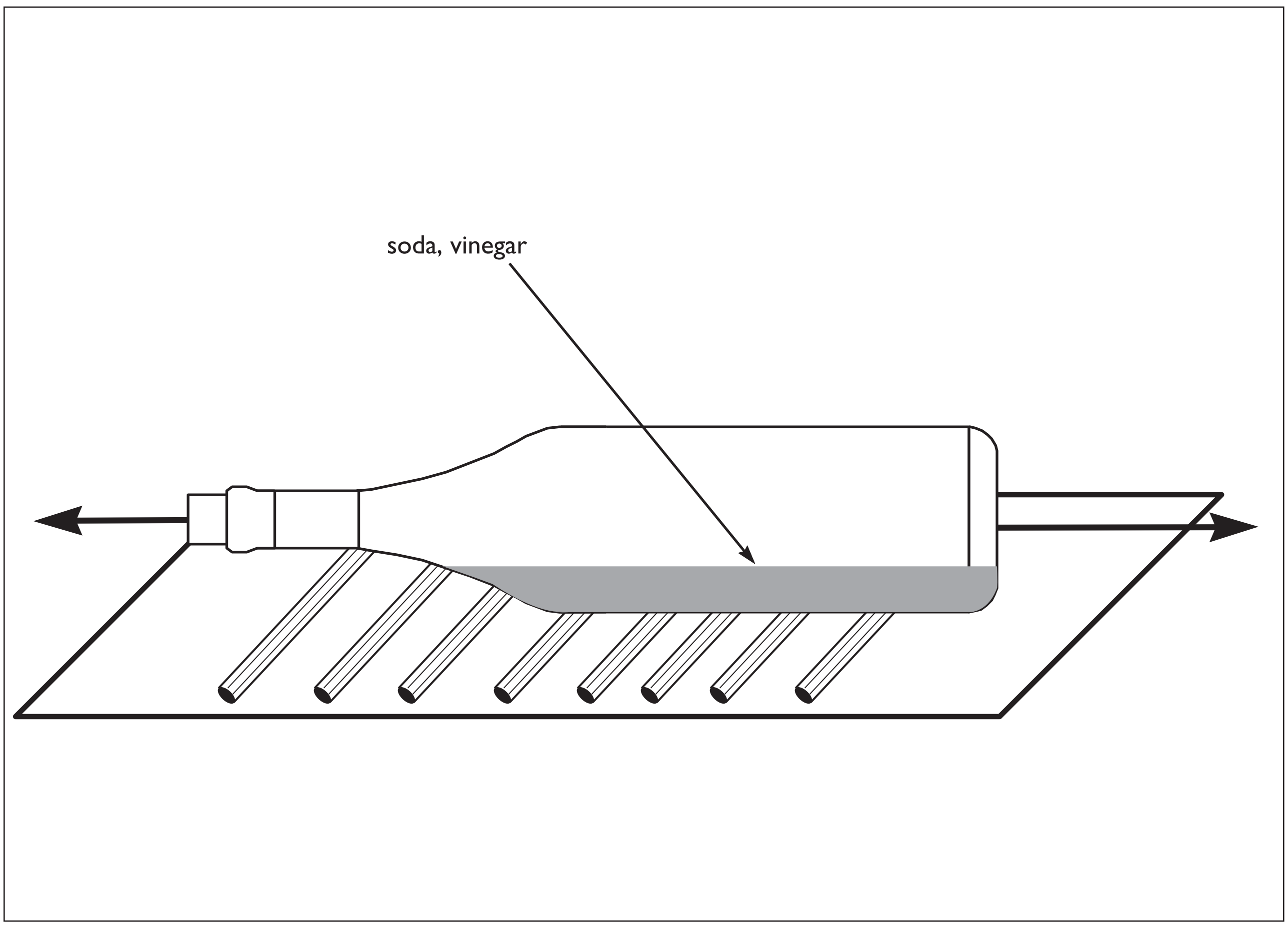


49. Space Can Make Your Blood Boil

Equipment Needed

500 ml flask or smaller, glass tumbler, stopper, tongs or pot holder, water, ice cubes, hot plate

Purpose

To demonstrate why astronauts need to wear pressurized space suits

Safety—Special Considerations

This is a demonstration which should be done by the teacher. You must be careful handling the hot flask and if the stopper does not seal the mouth very tightly, the water could come out. The flask should be made of Pyrex glass or similar borosilicate glass so that it can withstand changes from hot to cold (heat shock).

Grade Level—Time Needed

Intermediate grades; Time: 30 minutes

Background

The pressure of the air or other vapors that press on a liquid determine its boiling point. At sea level, water boils at 212 degrees F. At about 15,000 feet above sea level, water will boil at 98.6 degrees F, the normal body temperature. At about 10 miles up, your blood will boil at a relatively low temperature. The water in this experiment begins to boil again because the ice changes the steam back into water, lowering the pressure in the flask.

Procedure

Fill a flask half full with water and boil until steam drives out all the air. Use tongs or pot holder and remove from heat. Use stopper to close flask tightly. As soon as visible boiling has stopped, turn the flask upside down and set it in the tumbler. Place an ice cube on the bottom of the flask (now the top). The water will start to boil again and continue to boil until it is barely lukewarm. Ask the students why this happened.

Assignment

Write a paragraph to describe the activity and explain why astronauts use pressurized space suits.

Christian Application

It is amazing to consider how well created our bodies and their environment are here on Earth. For this we give glory to God. We would not survive out of our proper environment.

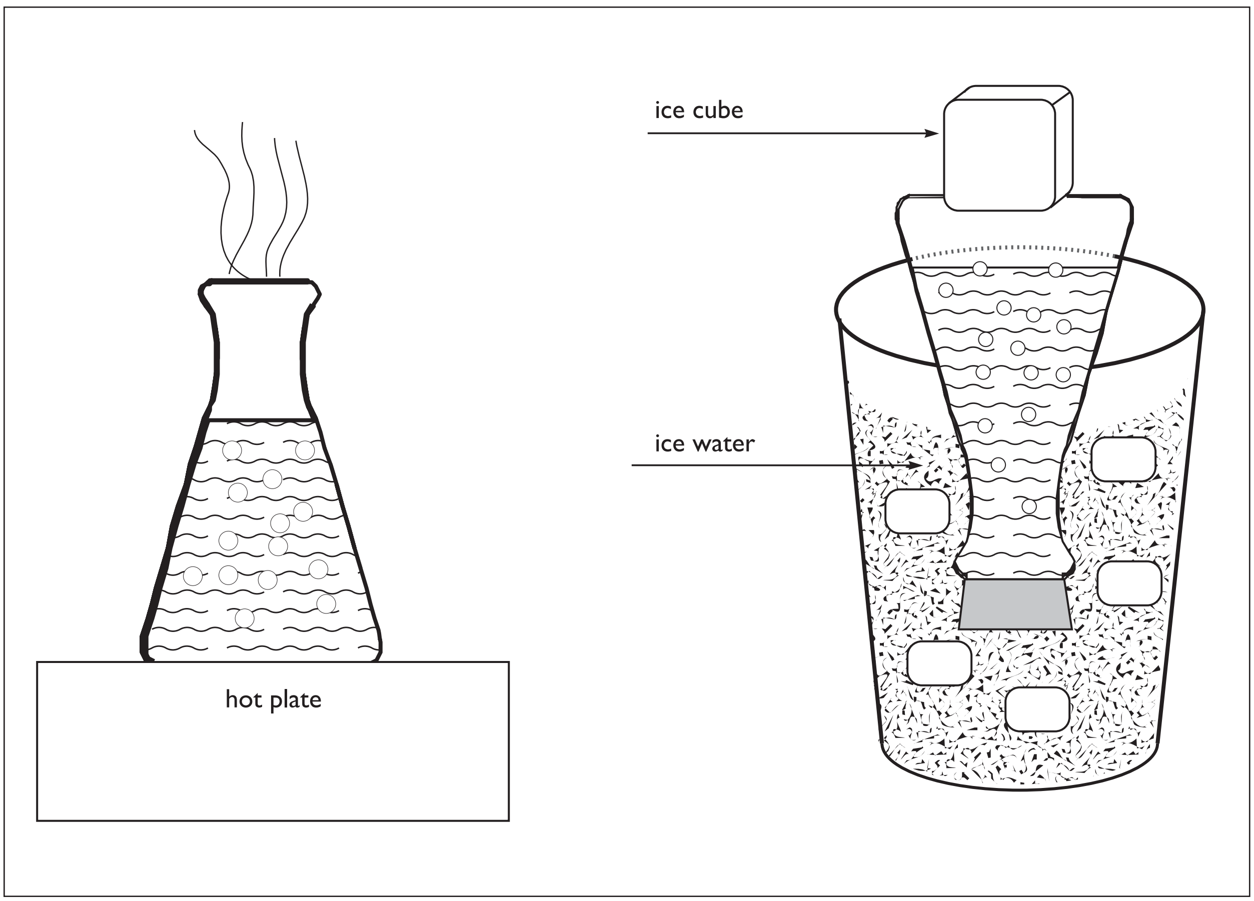
Extension

Research some of the NASA missions. Find out the goal of the mission, the astronauts who traveled in space, the date, etc. Write a short report including pictures.

References

Williams, Debbie and Carol Hickson. *Space Exploration: Demonstration Aids for Aviation Education V.2.* developed by Civil Air Patrol Center for Aerospace Education Development , FAA, 20 pages.

JP



50. Canny Planetariums

Equipment Needed

A black or opaque plastic 35mm film canister with a soft lid (one for each student), compass or other tool to poke holes, constellation worksheet, tape

Purpose

To make little planetariums for viewing constellations

Safety—Special Considerations

You could use the same idea on larger potato chip canisters which are easier to view but harder to store. The students should be careful poking holes.

Grade Level—Time Needed

Intermediate grades; Time: 20-30 minutes

Background

The constellations have been viewed by people for thousands of years. Different cultures see different pictures in the same pattern. People enjoy finding the patterns in the sky. You have to have a very good imagination to see some of the pictures that are in the patterns. Most constellations do not look anything like their name.

Procedure

Using the sharp tool, poke a hole in the bottom of the film canister as the viewing hole. You want a hole at leat $^{1}/_{4}$ inch in diameter for good viewing. Cut out a constellation circle from the choices and tape it to the lid of the canister. Use the sharp tool to poke holes for each star in the constellation. These holes do not need to be as large as the viewing hole. Remove the tape and paper. You can make many different constellation patterns and create a guessing game sheet by labeling the canisters with letters or numbers.

Assignment

Using a simple star atlas, encyclopedia or other library resources, find the patterns for other constellations so that different can planetariums can be made. They could also be used for other star projects. Use gummed stars and illustrate a known constellation on black construction paper, or create a new constellation with the gummed stars and give it a name. If you can find glow-in-the-dark paint, the students could paint the constellations on black paper and display them in a darkened room or on the ceiling of their bedrooms (with their parents' permission, of course).

Christian Application

We all know the lesson of God inviting Abraham to count the stars. It is unfathomable for us to understand that our God, who created countless stars of gigantic size, would show mercy and grace to us tiny creatures on a tiny planet in a tiny galaxy. Oh, what a wonderful heavenly Father we have! We say with David, "The heavens declare the glory of God, the firmament shows his handiwork." (See Psalm 8.)

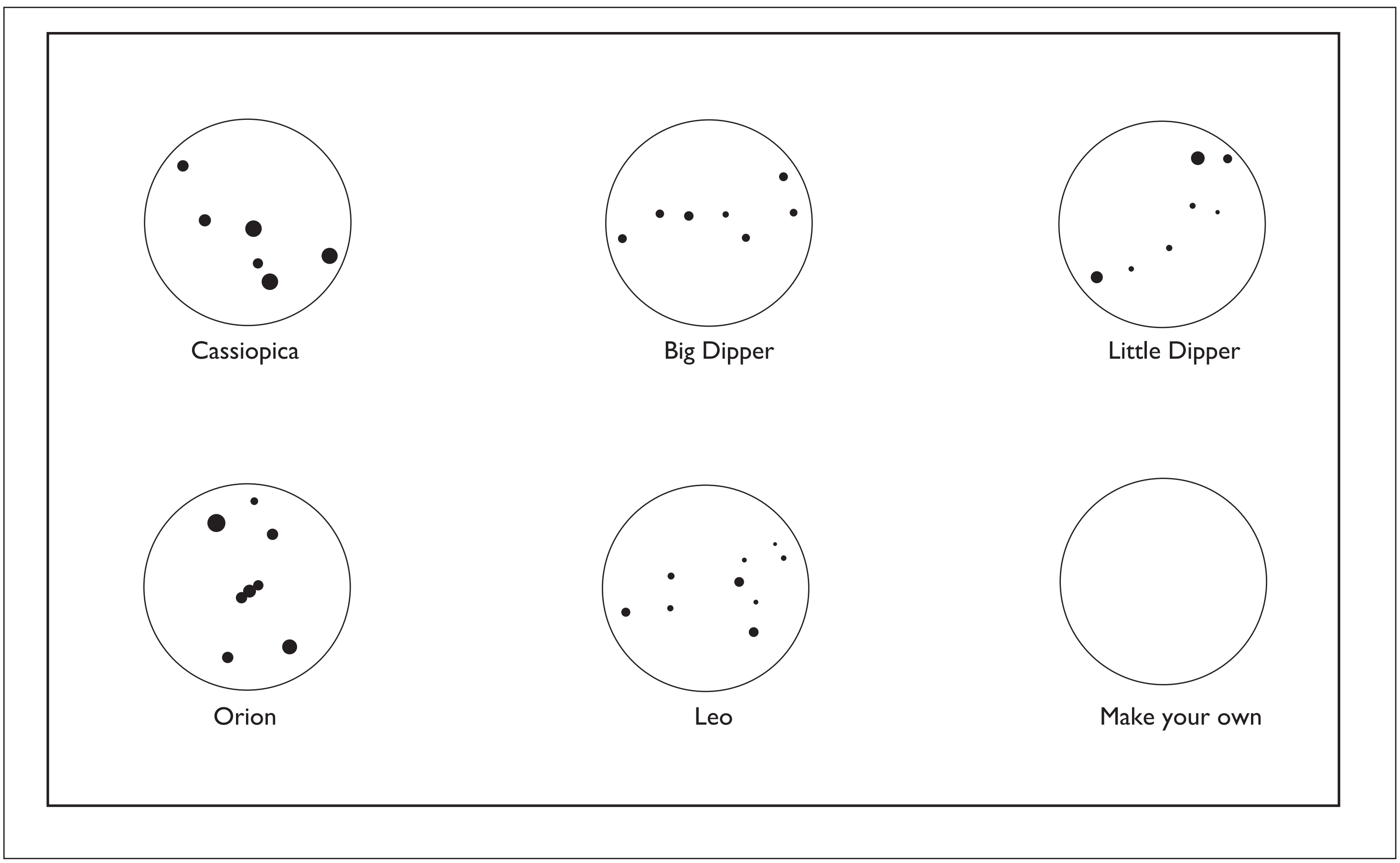
Extension

It can be fun for children to use the *Glow in the Dark Night Sky Book* which has the constellations that will shine in a dark room. It's a good way to learn to recognize the patterns. Some teachers might like to plan a sky-watching evening for the class and their families. Schedule it in a county park or a farm yard away from city lights.

References

Kominski, John. "Connect the Dots and Pinhole Constellations." *Nature Study,* 44(December 1991): 4. p. 10-11.

JP



51. The Heat Sink

Equipment Needed

Burner, metal lab tongs, aluminum foil

Purpose

To observe and experience the phenomenon of the heat sink principle
To apply the principle to space travel (heat ablation) and electronics (soldering transistors)

Safety—Special Considerations

Students should be aware of the possibility of a severe burn from the burner. Also, the aluminum will radiate heat energy quickly, but the tongs will remain very hot. The activity should be done on a fireproof surface. The used aluminum can be discarded in the trash.

Grade Level—Time Needed

Upper grades or high school physical science/chemistry; Time: one class period (20-50 minutes)

Background

Students should be familiar with the three types of heat energy transfer: conduction, convection, and radiation. Possible units include energy, space travel, and electronics. This activity can be used as a lab or demonstration. An ablative material will carry away something, in this case, heat.

Procedure

Cut a piece of aluminum foil 1"-2" square. Hold the piece of foil with the tongs near the center.

Hold the foil over a burner flame near the top of the flame (hottest part). If you use a Bunsen burner, the tip of the bright blue inner core is 3000 degrees Fahrenheit.

Results: The foil will burn leaving ash, all except for the portion in contact with the tongs and an additional margin of about $^{1}/_{8}$" around it. The metal tongs in contact with the aluminum foil are acting as a heat sink in draining away the heat from that portion of the foil, not allowing it to get hot enough to burn (its kindling temperature).

Assignment

Before the students place the foil in the flame ask them to predict what will happen to the aluminum. Students are usually surprised by the results. After the activity have them explain the results using the principles of heat transfer you had discussed earlier. Further work for older students can be found in the extension section.

Family Involvement

Students can take inventory of the cooking pots, pans, and utensils of the family kitchen and search for any type of heat sinks. (*Of what are most of the handles made?*) Water in a pot functions as an excellent heat sink. The oil in your car acts not only as a lubricant but as a heat sink. Ask if anyone has ever melted a cooking utensil. (Metal pots and pans can melt if they are dry.)

Christian Application

The unique properties of matter show God's wisdom in design and order in his creation of matter.

Extension

Research the use of ablative materials in spacecraft.

Discuss the use of heat sinks used in soldering electronic parts and transistors, where excessive heat would damage parts.

Upper level classes could work to design a heat sink that would make use of convection or radiation. A comparison could be made using the old "boiling water in a paper cup" demonstration. The topic of specific heat and metals makes a very good extension of this activity.

References

Atwater, Mary. et al. *Using Energy*. Grade 8. New York: Macmillan/McGraw-Hill, 1995.

Ontario Educational Communications Authority. "Eureka!: The Conduction of Heat" (video recording). New Jersey: Films for the Humanities & Sciences, 1981.

AM

52. Heat Treatment of Iron

Equipment Needed

Four bobby pins per student, 500 ml of cold water in a bowl, gas burners, matches, tongs, tape, lab tables

Purpose

To investigate the effects of heat-treating on the properties of iron

Safety—Special Considerations

Caution! Glowing red metal will burn fingers. Warn the students about this. The teacher should rehearse the activity to see that the pin becomes red-hot very quickly, much before the heat can conduct to ends being held by the investigator. Tell the students about this. Students will need to be focused on what they are doing. Everyone should wear protective goggles and the instructions must be followed as given. The usual precautions should be taken with matches and the burner. The four bobby pins used by the students should be taped to the lab sheet to avoid the pins being taken from the classroom.

Grade Level—Time Needed

Upper grades, high school physical science or chemistry; Time: 20 minutes plus discussion

Background

Students should be aware of heat energy transfer through conduction. A basic understanding of the atomic structure of matter is needed, yet this lab will work well as an introduction to atoms.

Heating a metal to a red-hot temperature causes the metal atoms of the material to move faster and more freely. This is why it is easier to bend the iron when it is red-hot. By allowing the iron atoms to slowly cool, more perfect crystals of iron are formed. This process is called annealing, to make soft. The more perfect the crystal of a metal, the easier it is to bend the metal when it is cool. The metal atoms can slide over one another more easily.

When the red-hot fast moving atoms of iron are cooled quickly, they form many small imperfect crystal structures. This makes the material hard but brittle. If this is followed by a gentle warming, called tempering. the atom can move to form a more perfect structure. The brittleness disappears and the spring returns to the hardened iron.

Procedure

- Tell the students that you will direct them through the lab. Emphasize that they must follow directions and show maturity. Then distribute the bobby pins. Have the students examine the bobby pins. Tell them to try bending one. Ask, *How easily does it bend?* (Not easily. It resists.) *Is it springy?* (Yes) Have them tape this bobby pin to worksheet with notes on its qualities.
- Have the students light their burners. Then they should grasp the open end of the bobby pin with their fingers and hold the bent end in the hottest part of the burner flame. As the pin heats up and glows red, they should bend it straight and remove it from the flame. This will happen very fast. Remind them to be careful not to touch the heated end. Place the hot pin on the base of a ring stand or some other suitable surface. Repeat this with the other two pins.
- Tell them to hold a straightened pin in the middle with tongs and to heat the entire

wire to a glowing red-hot temperature. Let it cool slowly. Repeat this with the other two pins.

- When the wires have cooled, tell the students to bend them into the shape of fish hooks. Ask, *Do the wires bend more easily now after they have been heated?* (Yes) *Are they as springy as they were before?* (No)
- Tell the students that the process of heating followed by slow cooling is called annealing (making soft). Next, tell the students to tape one of the three annealed hooks to their worksheets with notes on its qualities. Mark it, "annealed." Tell them to place the container of water next to the burner. Then holding one of the hooks with tongs, have them heat it to a glowing red-hot temperature in the flame of the burner. **Quickly** cool by dropping it into the container of cold water. Repeat this with the other hook.
- Explain that when the red-hot fast moving atoms of iron are cooled quickly, they don't have enough time to form into large ordered crystals. The quick cooling results in the formation of many small crystal groupings. The iron which is now hard but brittle, is said to be hardened. This type of iron is useful in making knives.
- Have them remove one of the hooks from the water. Ask them to try bending it. Ask, *Does it bend as easily as before?* (It will break.) Tape the pieces of this hardened iron to the worksheet. Have them mark it "hardened" and "brittle" on the worksheet.
- Have them carefully remove the other hook from the water. Then they should grasp it with the tongs and hold it way above the burner flame. Have them **slowly** lower it toward the top part of the flame until an iridescent blue coating forms on the hook. It must **not** be heated to a glowing red heat, so keep it out of the hottest region of the flame. Allow the hook to cool slowly.
- Explain that the process of gentle warming is called tempering. It removes the brittleness and returns the spring to the hardened iron. The crystalline structure of tempered iron is between the more perfect crystals of annealed iron and the irregular structure of hardened iron.
- Have the students try to bend this hook. Ask, *Is it brittle or springy?* (springy) Tape it to the worksheet with notes.

Assignment

The questions are asked and answered as the lab is completed. Research the use of iron in industry and examine the properties of iron.

Family Involvement

Perhaps a parent works in an iron foundry or with metals and would be able to speak to the class or bring in samples.

Christian Application

God has created matter to be complex and orderly by design, yet it can be manipulated for our many uses.

Extension

The students may ask to try different metals. Be sure the melting points are known so the correct amount of heat is applied. The *CRC Handbook of Chemistry and Physics* has a table of approximate melting points for commercial metals and alloys. Check the index under "melting point" for the page number in a particular edition. A discussion on alloys can result from the use of other pins or paper clips.

References

Schmitt, Harrison A. "Metal" *The World Book Encyclopedia.* Chicago: Field Enterprises, 1976, p. 349-350a.

Weast, Robert C. *CRC Handbook of Chemistry and Physics: A Ready-Reference Book of Chemical and Physical Data.* Boca Raton, FL: CRC Press, 1987 (68th Ed.).

AM

1. Survival of the Fittest

Equipment Needed

One 50 cm x 50 cm piece of floral fabric, paper punch to punch dots (some similar to fabric) from 5 different colors of construction paper (1 sheet each), containers for collecting dots

Purpose

To discover the changes that can occur in a species over several generations
To provide a basis for discussion of the acceptability of microevolution

Safety—Special Considerations

There are no hazards in this activity. Because the color of the species will cause a change in the relative frequencies (percentages) over several generations, this experiment will require extra dots.

Grade Level—Time Needed

Upper grades or high school biology classes; Time: 30 minutes

Background

A predator has certain characteristics which aid in its search for prey. God has given particular gifts to particular creatures. For example, many predators have binocular vision (both eyes focus on the same thing at the same time), whereas those animals which are preyed upon are more likely to have eyes on the sides of their heads which give them two pictures of the world (a wide angle provides optimum response to predator attack). A wolf's eyes have the positioning of a predator and a rabbit's eyes have a wide angle of vision of prey. Also, rabbits tend to stay alert and are poor sleepers.

Protective coloration is another characteristic of prey. The snowshoe rabbit changes color in the fall of the year and again in the spring of year.

Procedure

(pre-activity questions)

1. *How do a rabbit and wolf act towards each other? Why?* (The rabbit is prey, and the wolf is a predator.)
2. *Tell me what you know about a predator? Prey?*
3. *Have you ever heard of the Survival of the Fittest? What does it mean?*
4. *What is an adaptation?* (Develop the idea that Christians can see an adaptation as God's particular gift to a creature or a population of creatures.)

Place a piece of fabric on the floor (or table). Dim the room lights to simulate evening predatory habitats. Spread 100 paper dots (20 of each color) evenly and randomly on the fabric. Be careful to not overlap excessively. After the setup is complete, tell 2 or 3 students (predators) that they must capture as many prey as they can within the time limit. Then simultaneously allow the students to pick up (feed) from the piece of fabric (habitat). Have the predators use their non-dominant hand to feed. The feeding time should be timed and limited by the teacher to less than a minute to prevent the predators from totally eliminating the dots (prey). While feeding, the predators should take one dot at a time, and place each captured prey into the containers of its color before returning to capture another prey.

When the feeding is completed, each group of predators will count the remaining prey on their piece of fabric (habitat). Record the number of each color in the data table in the column labeled "Survivors, 1st Generation." All survivors double their numbers in the next generation.

Therefore, multiply the number in column A times two, and write the resulting number of dots in column C. Place the surviving dots and new dots of the proper colors on the fabric equal to the values in column C. Place all dots randomly on the fabric without overlapping.

Repeat the capture exercise, counting, and adding of prey until the data table is full (5 generations).

Assignment

Make a graph of the survival numbers of the data table. The horizontal (x-axis) line is the number of feeding times, and the vertical (y-axis) line is the number of remaining prey. Use different colored pencils to represent the different colored prey (see example of blank graph).

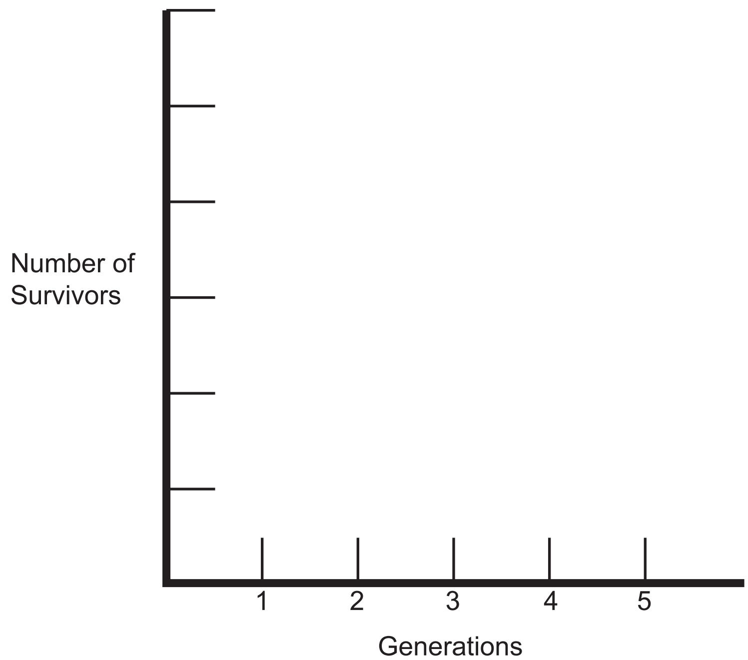
Equipment Needed

The idea of the survival of the fittest is often used by evolutionists to show how evolution takes place. This example, however, is only microevolution, and macroevolution (Darwin's theory) remains only a theory. Within our Christian beliefs we too can see how a population's characteristics can change over time because of certain adaptations it has. God has given certain abilities to predators and prey to help them survive. Because of their colors, size, speed, or whatever gifts they have been given, a population may change.

Extension

For more information read about the peppered moth and the changes in its population because of the Industrial Revolution in London.

	Survivors 1st gen			Survivors 2nd gen			Survivors 3rd gen			Survivors 4th gen			Survivors 5th gen		
Color	A	x2	C	A	x2	C	A	x2	C	A	x2	C	A	x2	C



Questions:

1. *What pattern do you see on the graph?*

2. *Why do you think this pattern results?*

3. *Can you name an animal that changes color?*

4. *How does this color change help?*

5. *Which color dot is the fittest? Why?*

The Peppered Moth

The peppered moth (*Biston betularia*) is common in England. These moths are nocturnal, that is they feed and are active at night. During the day they rest and attempt to hide from birds which feed on them. Before 1848, about 99% of the species were light gray. Less than one percent of the population differed in color and were dark gray speckled. These were so rare that, if someone added one to his insect collection, the local press reported the event. The two forms of the moth existed within the same habitat. The moths rested during the day on tree trunks which were covered with lichen. The lichen was also light gray speckled, and provided an excellent camouflage for the light gray moths. However, the more rare dark gray peppered moth was not so well adapted and was easier to find.

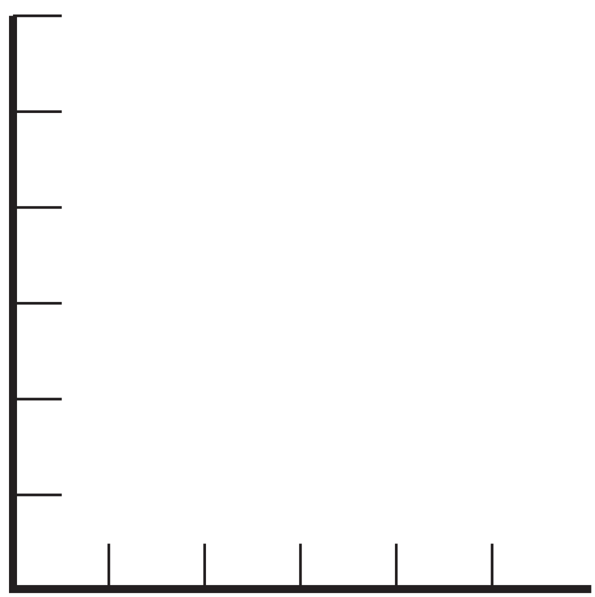
Around 1848 and continuing until around 1898, a surprising change occurred in the ratio of light-to-dark speckled moths. The industrial revolution came to England and brought with it pollution. The pollution had a two-fold effect. First, the trees were covered with soot from the factory smoke. Secondly, the lichens died from the soot and other pollutants because they are very sensitive to air pollution. Now the habitat of the moths was drastically changed. Instead of being well camouflaged on the trees, the light gray peppered moths stood out on the trees. Meanwhile, the dark gray speckled peppered moths suddenly blended very well with the bark. Soon 98% of the moths were of the dark gray variety.

In the 1930s, the geneticist E.B. Ford theorized the relationship between lichens and peppered moths, and in the 1950s this relationship was tested by H. Kettlewell. In his testing, Kettlewell documented that the ratio of light-to-dark gray peppered moths is directly related to the lichens. The more lichens on the tree, the more the light gray peppered moths will flourish.

References

Cummings, Michael R. *Biology: Science and Life*. St. Paul: West, 1996, pages 185-6.

RW and LR



2. A Field Investigation at a Nearby Stream or Pond

Equipment Needed

Copies of "Field Trip Observation Sheet," pencils, clipboards or notebooks to write on, dip net(s) (optional), shallow tray(s), eye dropper(s), forceps (tweezers), 10x magnifying glass(es), copies of *Pond Life* (A Golden Guide)

Purpose

To learn about the physical and biological factors that influence an aquatic ecosystem To learn what factors impact the health of a river or pond
To observe how an aquatic ecosystem may be degraded
To understand that human activity impacts ecosystems

afety—Special onsiderations

River banks can be slippery; do not get too close to the edge. Wear old shoes. If you suspect the water is polluted, avoid getting it near mouth, eyes or cuts.

Grade Level—Time Needed

Grades 4-8; Time: 45 minutes (plus travel time to and from aquatic site)

ackground

Water is vital for life on earth; rivers and ponds are habitats for many species. Wetlands are also nature's way of holding and cleaning dirty water. We also enjoy the beauty of aquatic areas and all the wildlife associated with them. We may also use rivers and ponds for recreation such as swimming or fishing.

Careless practices have led to the pollution of many of our rivers, lakes and ponds. Waste water from industry as well as from city sewer systems often flows into rivers without being fully treated. Non-point sources can be even harder to track, such as fertilizer runoff from homes and farms, and seepage of ground water contaminated by faulty septic systems.

The draining of wetlands can lead to flooding and loss of wildlife.

By recognizing the importance of aquatic ecosystems and understanding their problems, we can make informed choices as citizens to minimize our negative impact on rivers and lakes. We can even restore or improve these areas.

rocedure

- Distribute the "Field Trip Observation Sheet" to each student.
- Take the class to a nearby stream or pond.
- Have the students fill out the sheet.

Optional:

- Determine what organisms are living in the river. Dip into the water with a dip net and collect along the bottom. Transfer what you come up with into a shallow pan with a little water and examine it closely for living organisms. Use the *Pond Life* book or other reference to identify insect larva or other organisms.
- A large number and diversity of species indicates good water quality and a more stable ecosystem. Attempt to determine if the number and diversity of species you collect indicates good water quality or poor. Look especially for indicator organisms which are typically found either in polluted water or clean water.

Pollution intolerant organisms

organisms that are sensitive to pollution and are not likely to be abundant in polluted water. Their presence generally indicates good water quality.

caddisfly larva	mayfly nymph
stonefly nymph	hellgramite (*megaloptera)*
freshwater clam	water penny
riffle beetle	snails

Pollution indifferent organisms

organisms found in either clean or polluted water.

damselfly nymph	dragonfly nymph
crayfish	flatworm (*planaria)*
blackfly larva	cranefly larva
aquatic sow bug	clam

Pollution tolerant organisms

organisms found in either clean or polluted streams, but likely to dominate in polluted streams.

midge larva	blackfly larva
leech	mosquito larva
aquatic earthworms	tubifex (blood worm)

Assignment

Have the students turn in their completed observation sheets. Have students read and react to Genesis 1:9-10; 20-23.

Family Involvement

Students should discuss with their families ways they can minimize their impact on local waterways. Septic tanks should be properly maintained, and used oil or toxic substances should not be poured down drains or sewers.

Equipment Needed

Water is a precious resource for humans, animals and plants. It is a gift from God, and we will want to cherish it and will do whatever we can to protect it. We are to use the creation; at the same time we must be good stewards. All organisms modify the ecosystem in which they live but to damage any aspect of creation by careless use violates the entire law of God by despising his works and endangering our neighbors.

Students should learn that diverse ecosystems are more stable. All organisms are generally part of God's plan and have their place. Nevertheless, the creation is suffering because of sin, and many times what we observe is not what God intended.

Extension

Students could express their impressions of their visit to the river or pond by writing a poem or making a poster. Students could organize a clean-up of a river or pond area. Aquatic organisms could be brought back to the classroom for continued study. Students could draw aquatic organisms which they found.

References

Reid, George K. *Pond Life* (A Golden Guide). New York: Western, 1987.

SG

Field Trip Observation Sheet

Name:__________________________ Date: ____________ Time: __________ Group: ____________

Location of Observation:______________________________

Field Observations

As you approach the river or pond, observe the environment and record your observations. What do you see, hear, and smell?

What is the weather like? ____

____

For what is the nearby land used? ____

____

What kind of vegetation is along the bank?

_____ trees _____ grass _____ bushes

_____ flowers _____ other (describe):____________________________________

Are plants growing in the water? If so, describe them.

____

____

About how wide is the river or pond?

____

____

What animals (or evidence of animals) do you see?

____

____

Is there evidence of pollution? If so, what?

____

____

Do you think this pollution could be prevented? If so, how?

____

____

What other characteristics does the area have?

____

____

What is the bottom of the stream like?

_____ rocks & gravel _____ sand

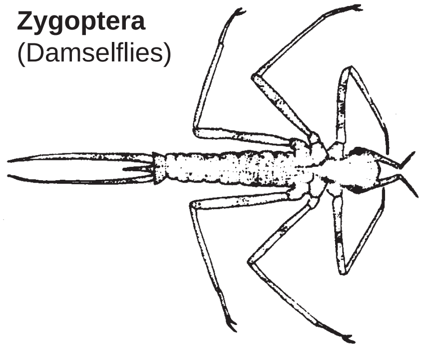
_____ solid bedrock _____ mud & silt

_____ other (describe):____

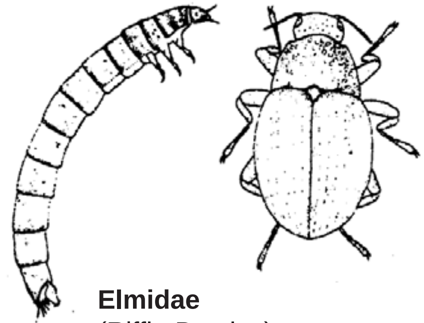
Draw a sketch of the site on the other side.

Field Trip Observation Sheet

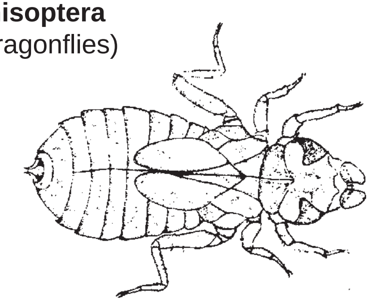
Zygoptera
(Damselflies)



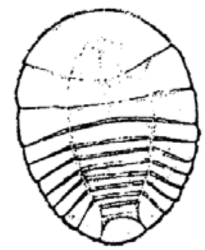
Elmidae
(Riffle Beetles)



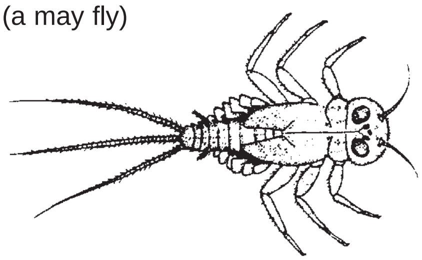
Anisoptera
(Dragonflies)



Psephenidae
(Water Pennies)

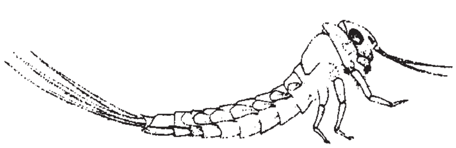


Heptageniidae
(a may fly)

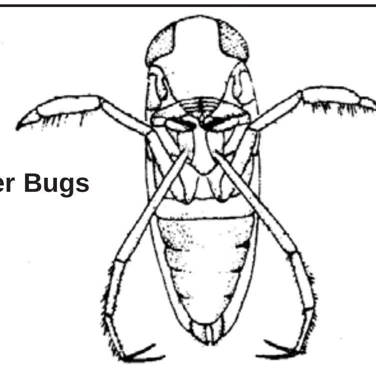


Ptilodactylidae
(a beetle)

Oligoneuriidae
(a may fly)

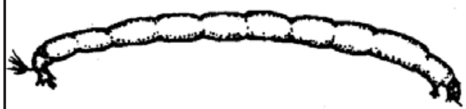


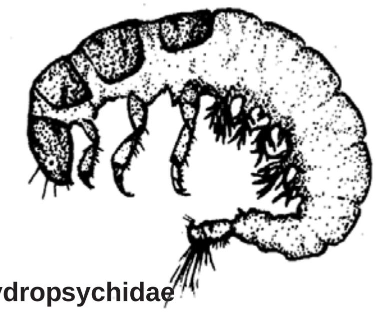
Water Bugs



Field Trip Observation Sheet

Chironomidae
(Midges)

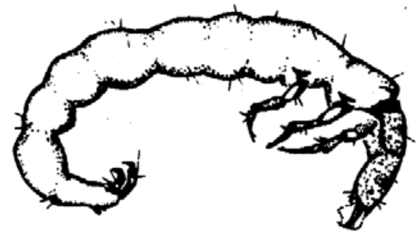




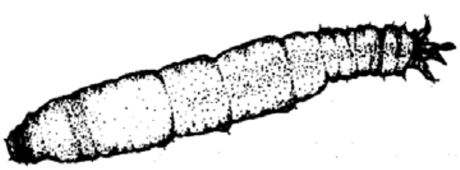
Hydropsychidae
(a caddisfly)

Simuliidae
(Blackflies)

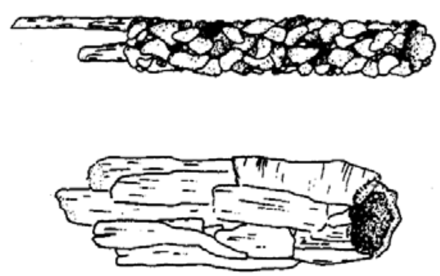
Philopotamidae
(a caddisfly)

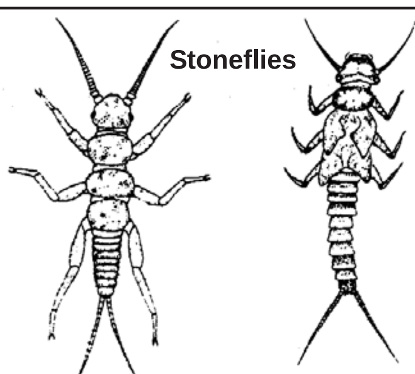


Tipulidea
(Craneflies)

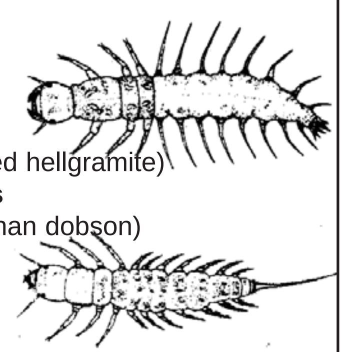


Additional Trichoptera
(a caddisfly)





Stoneflies

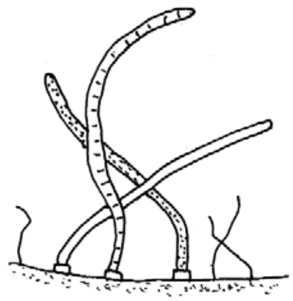


Dobson
(also called hellgramite)
Alderflies
(smaller than dobson)

Field Trip Observation Sheet

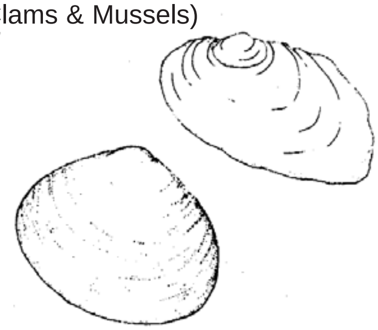
Platyhelminthes
(Planarians)
(a flatworm)

Tubifex
(Blood worm)



Drawing by Paul Boehlke

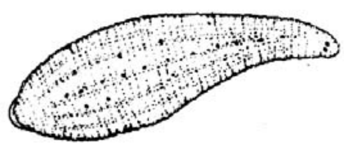
Mollusca, Pelecypoda
(Clams & Mussels)



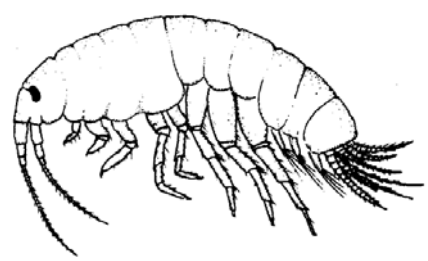
Annelida, Oligochaeta
(Aquatic Earthworms)

Crustacea, Isopoda
(Sowbugs)

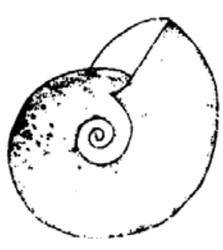
Annelida, Hirudinea
(Leeches)



Crustacea, Amphidopa
(Scuds)

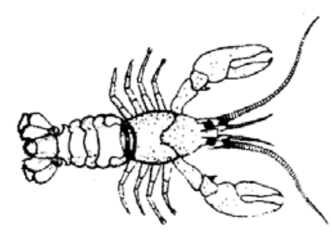


Mollusca, Gastropoda
(Snails)



Drawings on pages 3.8 through 3.10 are taken with permission from "Learning About a Waterway's Health Is in the Bag." *Chemecology,* March/ April, 1996, pp 7-10

Crustacea, Decapoda
(Crayfish)



3. Water Distribution Demonstration

quipment leeded

A 1,000 ml (1 liter) container such as graduated cylinder, beaker, kitchen measuring pitcher, or soft drink bottle; a smaller graduated container such as a 100 ml graduated cylinder, a beaker, or a measuring cup; four small clear containers such as beakers, glasses, or baby food jars; water; food coloring (optional but a good idea)

Purpose

To demonstrate the distribution of Earth's water

Safety—Special Considerations

Handle glassware safely. Use plastic where possible. Scientists measure water levels in graduated cylinders by sighting the bottom of the meniscus (curvature of the water level).

rade Level— ime Needed

Grades 3-8

Background

Humans must have fresh, clean water to live. But about 97% of the Earth's water is too salty for humans to use. The remaining 3% is fresh water, but most of it is in polar ice caps, remote glaciers and icebergs and is not easily accessible. Accessible fresh water , therefore, comes from streams, lakes and underground sources. It is important to keep these sources as clean as possible.

Procedure

- Fill the large container with 1,000 ml (1 liter) of water. You may add food coloring to make the water more visible. Tell the students that this represents the earth's entire supply of water.
- Pour 28 ml of the water into the smaller graduated container. This represents the Earth's fresh water. The other 972 ml represents the saltwater which is found primarily in oceans. Set this aside or pour it out while asking the students why this water is largely unusable. (The salt does not allow our bodies to use the water.)
- Distribute the 28 ml of freshwater into the four clear containers as follows:
  - 23 ml into the first one to represent the water locked up in icecaps and glaciers. Lead students to understand that this water is largely inaccessible.
  - 4 ml into the second container to represent ground water, some of which we can use, but much of which is difficult to get at.
  - 1 drop into the third container to represent the water in the atmosphere and topsoil.
  - 2 drops into the fourth container to represent surface water. This is the water in our lakes and streams which we use for recreation, and which is important for wildlife. It is also the water supply for many people.

Assignment

Have the students construct a pie chart or other graphic representation of the distribution of water on Earth.

Family Involvement

Students could do a home water use survey and compare their family's use to the national average of 70 gallons per day per American. The family could try to find ways to save water. Many older toilets use too much water to flush. Putting a brick or a plastic bottle filled with water inside the toilet tank could save water. Showers generally use less water than baths. A person could take a shower without draining the water to compare the amount of water used for a shower with the amount a bath would take. Students could report back on the methods being used at home.

Equipment Needed

Water is part of God's wonderful creation. He gives us all of the water we need, but we will want to be good stewards of this gift.

Extension

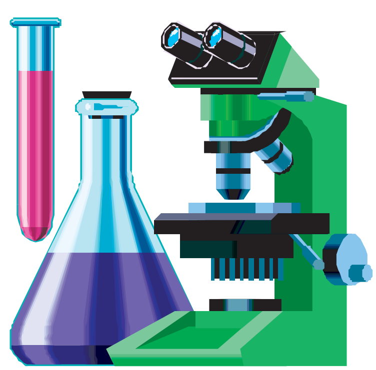
Have students imagine that their water supply system has been knocked out of commission. They have to use water trucked in from another location. They are only allowed five gallons per person per day. Have students decide how they will use their limited supply of water.

References

American Water Resources Association
5410 Grosvenor Lane, Suite 220
Bethesda, MD 20814-2192
Telephone: (301) 493-8600

SG

“*We are to use the creation; at the same time we must be good stewards.*”



4. Making Recycled Paper

Equipment Needed

A blender, waste paper (newspaper or other used paper, do not use shiny paper such as magazines), plastic dishpan, piece of window screen (at least 6x6 inches), large towels or dishcloths, iron to press paper (optional), bucket (at least one gallon)

Purpose

To learn how a resource can be recycled

Safety—Special Considerations

Tape all screen edges where wire mesh is exposed to prevent cuts. Do not operate the blender without the lid on. If an iron is used beware of burns. Steam is especially quick to burn a person. Clean up all equipment promptly, but do **not** dispose of the waste pulp by pouring it down the drain. It can plug the drain.

Grade Level—Time Needed

Grades 3-10; Time: one class period plus preparation time

Background

Paper is made from a variety of materials, but most is made of wood pulp from trees. The pulp is beaten until it is separated into its individual fibers. The fibers are spread out on a screen and as they dry, the tangled fibers become paper.

Recycled paper is made using a similar process, but recycling requires less energy and saves trees. Every ton of paper recycled saves around 18 trees. Recycling also conserves and protects other natural resources. It uses 70% less energy and 60% less water, and reduces pollutants by 50%. If we throw paper away, it must be burned or landfilled. Paper does not break down very fast in a landfill.

Americans make up only 5% of the world's population but produce over 37% of the world's garbage. Paper waste is the largest single component of our garbage (about 40%).

Procedure

- At least one hour in advance, have the students tear several pieces of waste paper into very small pieces or strips and soak the paper in a bucket of warm water for an hour.
- Begin the activity by asking the students: *From what is paper made?* (cellulose fibers from cell walls in plants) *What makes wood a good material for making paper?* (lots of long fibers) *How do you think paper is made? Can you use old paper to make new paper? How do you think recycled paper is made?*
- Fill the blender about one-third full of warm water and add an equal amount of the waste paper pulp from the bucket. Put the lid on. Blend thoroughly.
- Fill plastic dishpan about one-half full of warm water. Pour pulp mixture from blender into the dishpan of water.
- Slide screen into the dishpan of water/pulp. Lift the screen straight up, catching a thin layer of pulp on the screen. Be sure the entire screen is covered with pulp. If the entire screen is not covered, resubmerge the screen and try again. Allow excess water to drain off.

* Place screen, pulp side up, onto a towel to remove some of the moisture. Flip screen over (pulp side down) onto a dry part of the towel. Carefully peal the screen away from the pulp. Smooth dish towels work a little better than bath towels with a thick nap; the paper comes out with a smoother texture.

- Blot the top of your new piece of paper with a dry section of towel. You should now be able to peal the paper off of the towel. Continue to blot the paper to remove more of the mois-

ture. Lay the paper aside to dry thoroughly.
- (Optional) To speed drying, you can use an iron to press it flat and dry. Use a layer of towel or other fabric between the iron and paper. Another way to speed drying is to place the damp paper in front of a fan or blower. The edges can be squared off using scissors or a paper cutter.

Assignment

Have students monitor the use of paper in the classroom. Have them brainstorm ways to reduce paper use and/or to reuse or recycle paper. Let the class decide which ways can be carried out. After a week evaluate the new procedures.

Family Involvement

Have students monitor their family's use of paper for one week and determine which household activities use the most paper products. Students should suggest ways their families could cut down on their use of paper products. They should also find out if their family recycles paper and if not, why not?

Christian Application

We want to be good stewards of the resources God supplies. By reducing our paper use and recycling paper, we preserve our forests and other resources. Garbage is also a serious problem. We need to view garbage as God-given resources that are out of place.

Extension

- You can make your screen more rigid and useful by tacking it onto an old wooden picture frame (or make your own frame for it out of scraps of 1x2 wood.
- Students can make colored or scented paper by adding food coloring or cologne to the pulp.
- Try adding a cup of laundry starch to the pulp/water to increase fiber bonding.
- Try adding a small amount of bleach to the pulp/water to make whiter paper. (Caution: Bleach is toxic and can bleach student clothing.) Discuss the large-scale use of chlorine to bleach paper. The chlorine ends up in the waste water as a pollutant. *Do we really need snow-white paper or would we be willing to use off-white paper in trade for cleaner water?*
- Art Connection: Drip food coloring onto wet sheets; add leaves or other objects by pressing into the wet pulp; paint on dry recycled paper; press pulp into molds and paint when dry.
- Discuss other resources which can be recycled: aluminum, plastic, glass. *In what ways are these similar to paper recycling? How are they different?*

References

Fletcher, Helen Jill. *How on Earth Do We Recycle Paper?* Fresno, California: Millbrook, 1992.
Gibbons, Gail. *Paper, Paper Everywhere.* San Diego: Harcourt Brace Jovanovich, 1983.
History and Story of Paper Making: an Industrial Romance. Parchment, Michigan: Kalamazoo Vegetable Parchment Company, 1934.
Meador, Karen. "Garbology: Detective Work in People's Trash" *Teaching K-8* (April 1996) 46-48.

SG

5. Before and After Brushing: An Investigation

Equipment Needed

Sterile plastic Petri dishes (one/student), agar (Ward's sells an instant medium called Redigel™, however, using a recipe is not difficult), sterile cotton applicator swabs from a drug store (two/student), permanent marker to write on Petri dishes

Purpose

To investigate whether brushing teeth lowers the number of bacteria present
To motivate students to brush their teeth

Safety—Special Considerations

Warn students that some bacteria can cause disease. They should not accidentally share swabs or contaminate anything (like the table top). The Petri dishes should be kept closed once they are inoculated.

Proper disposal of the cultures and any contaminated material is important. All actively growing cultures in the Petri dishes, contaminated glassware, and equipment should be autoclaved at 120°C, 15 psi for 15 minutes. Before doing this activity be sure that you can do this or make arrangements with another school to do it for you. If you do not have an autoclave, a pressure cooker can be used. Add water below the rack with the materials and follow the manufacturer's directions when operating. "Cook" for at least 15 minutes.

Table tops or anything that may have become contaminated should be cleaned with 70% iso-propyl alcohol, household bleach, or 10% Lysol. Cover area with paper towels and saturate them with additional disinfectant. Wait 30 minutes. Clean up wearing rubber gloves.

Grade Level—Time Needed

Upper grades or high school biology classes; Time: one 45-minute class to set up the cultures, observations of the cultures on at least two or three successive days thereafter, so start early in the week

Background

Agar (AWH-grr) is derived from algae originally harvested in New Guinea. Agar-agar is a local word in New Guinea for the red algae that is harvested for this purpose. Have students find New Guinea on the world map. This algae also grows in other places. (Check *World Book* under "Agar.")

Bacteria are single-celled organisms. (Bacterium = one; bacteria = more than one.) There are many species. They can double their numbers by cell division (mitosis) every twenty minutes under ideal conditions. Students may wish to do some calculating here. Fortunately, they slow down when they are crowded or they would take over the earth. Even so, they are almost every-where. Many bacteria are useful, some are harmful. Bacteria have their role especially in breaking down materials and recycling. Water waste treatment plants encourage growth of the bacteria in their holding tanks. This breaks down wastes that we flush into the sanitary sewer system. Some bacteria that live inside our small intestines make vitamin K (necessary to clot blood) for us. These bacteria pay rent for living inside us. Some species of bacteria can digest oil and clean up accidental spills. Bacteria are part of God's planned creation and help to recycle materials in nature.

Eating between meals, especially sweets, is a good way to furnish the bacteria in your mouth with lots of food. This will encourage their growth. Eating an apple at the end of a meal can help clean your teeth.

In our mouth bacteria produce CO_2 (like we do) which combines with water to form carbonic acid. This acid can react with the mineral compounds (calcium phosphate, calcium hydroxide, and calcium carbonate) in our the teeth and can cause cavities. The teacher could put a piece of chalk (calcium carbonate) into vinegar which is an acid to show the reaction. Fluoride in toothpaste kills bacteria. Fluoride in drinking water builds a harder tooth enamel in children which is about three times as resistant to cavities. Baking soda is an economical toothpaste with a different taste. The act of brushing is more important than the choice of a brand of toothpaste.

The major way in which bacteria are transferred from place to place, from person to person, is by the hands (more than coughing and sneezing). Our hands usually find their way to our mouth and nose. We need to wash our hands often.

Procedure

The teacher should prepare a Petri dish for each student the day before the exercise. The agar may come with a recipe. If not, a typical recipe is to weigh out 23 grams of a general nutrient agar. Add the agar to one liter of distilled water. Warm and stir to dissolve the agar, then heat to boiling. Bringing the mixture to a boil too fast will burn some of the agar. (The solution could be autoclaved at this point to be sure that it is sterile, but this activity will work if you skip this step.) Add enough solution to each Petri dishes to cover the bottom surface. Immediately cover the dishes after pouring to prevent unnecessary air contact. The agar will solidify as it cools. Pour until all of the solution is used, saving extra plates for additional experiments. One liter can make about 40 plates. Store them up-side-down. Refrigerate.

- Students should be told to come to school without having brushed their teeth. (Yes, Mom, the teacher really did say that.) They should bring along their toothbrushes and some toothpaste (in wax paper).
- Give each student a Petri dish (culture plate). Tell the students not to open them until they inoculate them. Divide the Petri plates in half with a permanent marker. Mark one side "B" for "before brushing," the other "A" for "after brushing." Be sure to make a mark on the bottom dish so that the top can be aligned with it. The dishes should also be labeled with a code (such as initials) for each student.

- Give students sterile cotton swabs and have them rub it along the front and back of their teeth. Then they should lightly move it back and forth on the "before" side of the agar plate. This is called streaking the plate. Try not to tear the agar. Immediately close the Petri dish. Place the used swabs into a labeled beaker to be autoclaved and discarded. Do not allow swabs to touch the table tops. Be sure swabs are not accidentally shared or reused.
- Now the students should go to the washroom to brush their teeth. The teacher might wish to review proper brushing techniques first: (1) Brush up and down. Vertical movement in brushing is very important. Place the toothbrush toward the gums and, by turning the wrist, move the brush toward the tongue. (2) Do not brush extremely hard. This could eventually wear groves in the teeth. (3) Be sure to brush both sides. (4) Also lightly brush the tongue. (5) Just like doing the dishes, rinse the brush and mouth and re-brush. (6) A good brushing should last three minutes. (7) Brushing after each meal (three times/day) is ideal.
- Students should take a second cotton swab and run it along the teeth in the same way as they did before. This time they should streak the "after" side of the plate in the same way they did the first. Students can be told that scientists try to control all variables except one. Ask students what is being allowed to vary in this experiment? (brushing the teeth)
- Have the students tape the Petri dishes with clear tape. Store the plates up-side-down to prevent any condensation inside the dish from dripping on the surface of the agar. Put them aside in some safe place within the room. Put a warning sign on them for people who are not part of the class: "Bacteria Cultures - Do Not Touch." Inspect them at 24-hours intervals by looking through the dish. Do not open the dish. Each spot of growth is a bacteria colony with many bacteria cells. Count the number of bacteria colonies on each side at each 24-hour interval. Record data. It is acceptable to record "too many to count" if the colonies

completely take over a side of the plate. Share data by making a table on the board which shows which side of the plate had the most growth. Scientists generally like to have a large sample size rather than depending on only one experiment. Answer the question: *Does brushing lower the number of bacteria in the mouth?* If the students had run only one Petri plate, could they have come to the wrong conclusion? (It is possible that a few plates may yield opposite results because of variables that were not controlled.)

- The Petri plates should not be opened. Keep them sealed. Dispose of them according to the directions in the safety section.

Assignment

Have students plan and design an experiment that could be done with bacteria. Share ideas with the class. Have the class react to the ideas.

Family Involvement

Students should share the results of the activity with their family.

Extension

The complexity of the creation and its many life forms are impressive. Bacteria grow so fast that we know that they can change their genes (mutate) and evolve into a population of organisms with new properties. Beta-hemolytic group A streptococcus causes strep throat. In the 1940s this bacteria could be stopped with only 5000 units of penicillin. Now it takes one million units. Even with that number, 12 to 17% of infections are not fully eradicated (Brody). The creation is dynamic and exhibits a flexibility that is called microevolution. Some people assume that life could have begun in this manner (macroevolution); but such assumptions are also wrong. This is not how life started on our planet. God has plainly told us in the Bible that he made us and all life forms in the beginning. While bacteria may change and can even be called a new species, they are still reproducing after their own kind. God is our creator and preserver.

Christian Application

Other experiments can be done with culture plates. Students could take on different projects and report on the results.

- Plates could be left open to the air, while others are closed in the same location as a control. This experiment will show that bacteria is airborne.
- The effectiveness of lowering the temperature can also be demonstrated. Plates could be inoculated. Some could be kept at room temperature while the others are placed into the refrigerator.
- Different brands of toothpaste could be compared.
- The cleanliness of surfaces around the school could be compared in the same way as the effectiveness of brushing teeth was studied.
- The effectiveness of antibacterial cleaning products or antiseptics could be studied.
- Students could conduct a study of how many people wash their hands after using the wash room.

The possibilities are endless, but students will have to be sure that they control all variables except the one of interest. This is a key to understanding how a good experiment is set up. In all cases be sure that the plates are not opened after inoculation and that they are disposed off by autoclaving (see safety section).

References

Brody, Jane E. "Strep Throat Settles into Families Often with the Aid of the Afflicted." (Minneapolis) *Star Tribune* 24 March 1996, page E5.

Morholt, Evelyn; Paul F. Brandwein; and Alexander Joseph. *Teaching High School Science: A Sourcebook for the Biological Sciences*. New York: Harcourt, pages 380-5.

Ward's Biology (Catalog), (PO Box 92912) Rochester, New York 14692-9012, 1996, pages 5-24.

The World Book Illustrated Home Medical Encyclopedia. Chicago: World Book-Childcraft International, 1980, pages 936-7.

PRB

"*Be sure to brush only the teeth you wish to save.*"

6. Bone #1: The Observation of Mammal Bones

Equipment Needed

Fresh beef or pork bones, paper toweling, tray to display bones, scalpel or sharp knife, probe, hand lenses for student use

Purpose

To observe directly the characteristics of animal bones to see their similarities to human bones

Safety—Special Considerations

Find a friendly butcher. Note that some butchers may need several days' notice to fill your request and that some grocery stores may get their meat already processed. Try to get a variety of cleaned, uncooked animal bones (beef soup bones, leg bones, ham hocks—the butcher may even suggest some interesting bones you had not anticipated. Remember to tell the butcher that you need these bones for educational purposes. They may be free of charge.

The long bones should be cross-sectioned with a hacksaw to reveal their structure and composition as shown in the accompanying sketches. Keep the bones cool until class time. Caution students to handle the cut bones with care. Students should wash their hands following this activity. The scalpel or knife should be used only under supervision.

Grade Level—Time Needed

Grades: intermediate and upper; Time: one class period (This lesson is the first of three.)

Procedure

Tell the students to observe and handle the provided bones. Encourage students to express their observations about the shape, texture, and composition of the bones. Have the students answer the following questions. *Are bones solid?* (No, only some parts are.) *What would happen to their overall weight if they were? Can you find the bone marrow? Can you tell from what part of the body a particular bone comes?* Student observations may be recorded on the chalkboard or in notebooks. If teams of student are given different bones, they can also be asked to share their observations at the end of the session.

Assignment

Tell the students that the class will generate a list of the main bones in the human body for the next class period. Have some students list the bones in an arm. Others can list another part of the body.

Christian Application

God has made many things in animals similar in design to humans. His good designs in nature are repeated. Therefore the study of animals allows us to discover many things about ourselves. Sometimes animal parts can even be used to help humans. The similarities are a great blessing for the study of anatomy, physiology, and medicine.

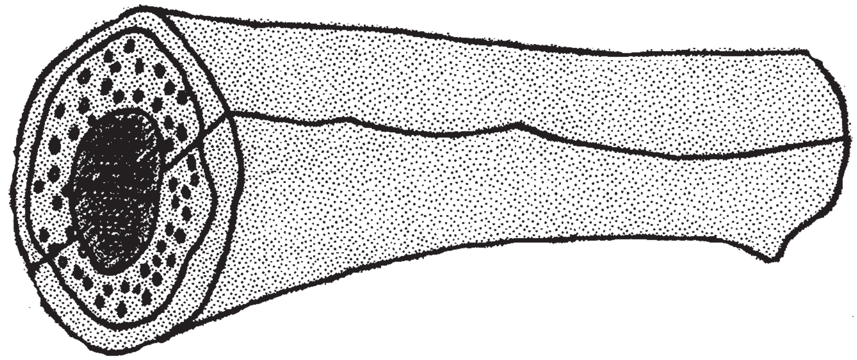
Extension

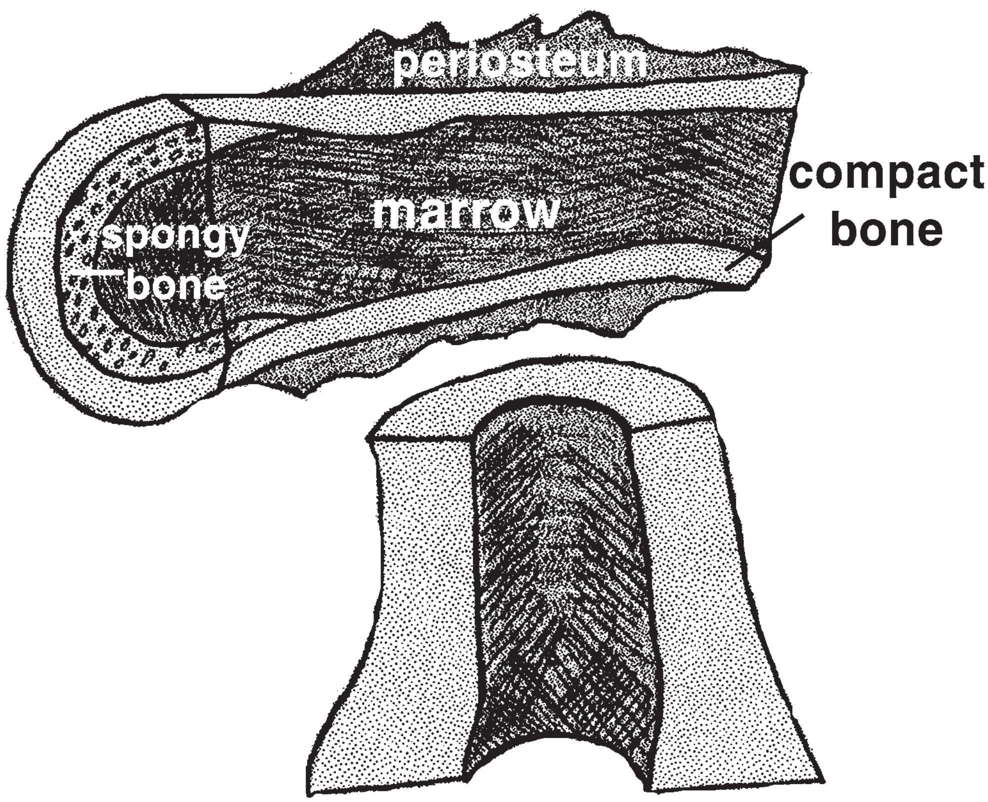
Students may conduct similar observation sessions with turkey or chicken bones. Remove the marrow from a bone by scraping it out carefully. Clean the bone by boiling it. Look along the lines of stress for the struts and braces. Joints can also be studied.

HJ & AU

Bone Diagrams

Cleaned long bone





Boiled and scraped long bone, sectioned

7. Bone #2: Making a Bone Model

Equipment Needed

The drawing in this book and modeling clay or play dough, knife, paper, scissors, toothpicks

Purpose

To learn the parts of long bones

Safety—Special Considerations

Collect materials suggested before class period. Students may work with partners.

Grade Level—Time Needed

Intermediate grades; Time: one class period (This lesson is the second of three.)

Background

A long bone is not solid throughout. Marrow and spongy layers fill the center of the bone but are lightweight. The layers include the periosteum [pair'-ee - os' - tee - um] which is the outer covering that produces the bone cells that make and remodel the bone. Next on the exterior is compact bone which provides hardness and strength because of its highly organized layers. There are blood vessels in it and bone cells (osteocytes). The lightweight spongy (cancellous) layer has fat cells, larger blood vessels that run through it, and the red marrow [mare' - oh]. Cancellous bone is found mostly on the ends of long bones. The red marrow inside produces red blood cells. Cartilage [kart - uh - lidge] is smooth tissue found at the ends of bones and at joints (places in the body where two or more bones come together and movement can occur).

There are three different bone cells: osteocytes [awes' - tee - oh - site], osteoblasts [awes' - tee - oh - blast], and osteoclasts [awes' - tee - oh - clast]. The osteocytes are fixed into the solid calcium matrix. These cells allow nutrients and gases to move throughout solid parts of the bone. The osteoclasts take the bone apart. (Associate the term with the the word "iconoclast." During the Reformation Luther stopped his followers from breaking icons of the saints.) While the osteoclasts are being destructive, the osteoblasts are putting the bone back together again. Hence, bone is constantly being remodeled, strengthened, and repaired. It is a living material as long as we are alive.

Procedure

Distribute supplies and a drawing of the bone. Guide students in making their models.

Assignment

Cut across the clay bone model and label bone parts.

Christian Application

The design, relative strength, and intricacies of the long bones show us that we are "fearfully and wonderfully made" (Ps 139:14). God has blessed people with a living inner structure which supports, shapes, and allows body movement. Even though the long bones in the body withstand perhaps the greatest day-to-day stresses, God has designed them to be very strong but lightweight enough so we can move quickly.

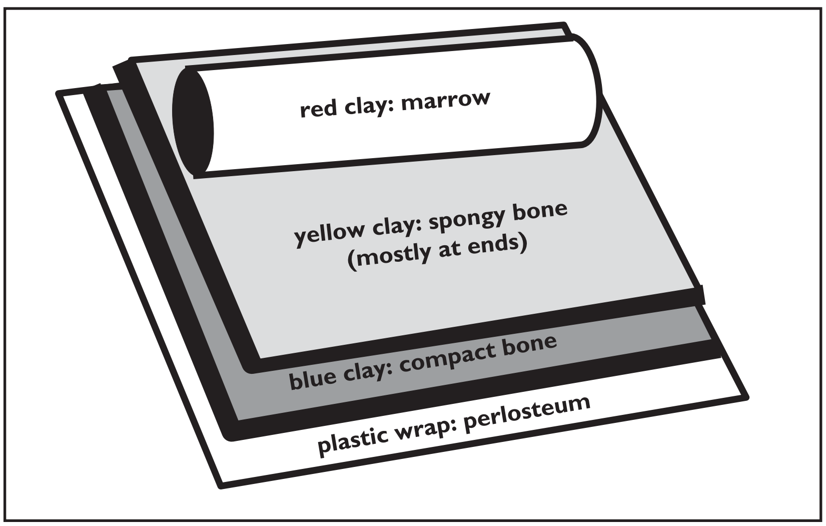
Students will hear Ezekiel's vision with a new appreciation. Read Ezekiel 37: 1-14.

Extension

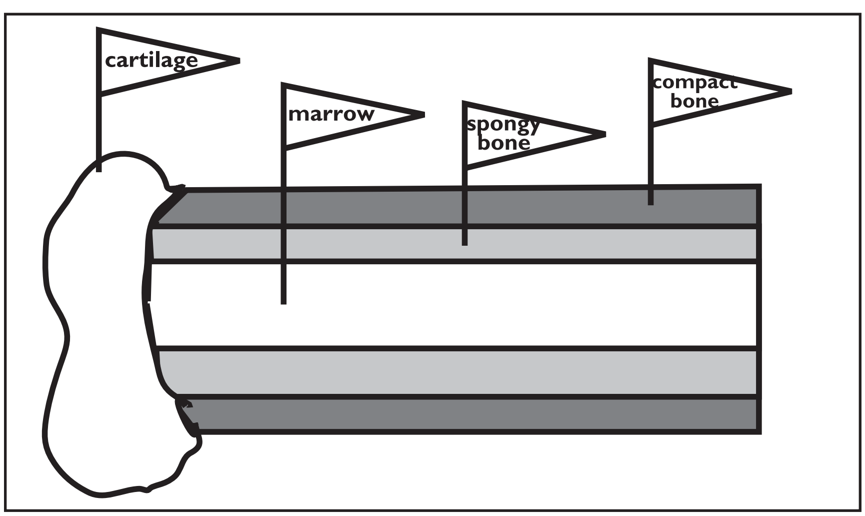
Students may exchange models and check the models of their peers for accuracy. Students may also demonstrate their knowledge of long bone composition by explaining the accuracy of a peer's model either verbally or in writing.

AU & HJ

Clay Model of a Long Bone



Cross Section of a Clay Bone (with cartilage end)



8. Bone #3: Function of the Makeup of the Bone

Equipment Needed

Two index cards, masking tape, and assorted textbooks for each student.

Purpose

To show the relative strength of the round bones

Safety—Special Considerations

Students should use care when placing books on top of the index bone models. They should anticipate how the books might fall and keep them from falling off a table or hitting other objects.

Grade Level—Time Needed

Intermediate grades; time: one class period (This lesson is the third of three.)

Background

Human bones provide the body with a shape, the ability to move, and protection. Bones are amazingly strong for their weight, and they can withstand great amounts of pressure. A long bone can withstand stresses of up to 24,000 pounds per square inch. Every step that a medium-size person takes puts about 12,000 pounds per square inch of pressure on the femur (thighbone). Despite their strength, bones are lightweight enough to be moved easily. The cylinder, which is basic to the structure of all long bones, is one of God's strongest geometric forms.

The form (structure) matches the function is a major presupposition in anatomy.

Procedure

Tell the students that the index cards will function as models of bone structures. Scientists often build models. Fold one index card in half. Predict the number of books (books of the same size) the folded card will support. Gently place books (one by one) on the bone model (representing a flat bone) until it collapses. Record total number of books the bone model will support.

Form a second index card into a cylinder using tape to secure the edges. Predict the number of books that the card will support. Gently place books (one by one) on top of the cylinder (representing a long bone). Record the total number of books the bone model will support.

Assignment

Write a statement about how God provides the right bone for each part of the body. Give an example to support the statement. Graph results of predictions and actual totals. Using the results of this activity, suggest reasons that God placed such strong bones in the places he did.

Christian Application

God, in his wisdom, provides the human body with bones that make life and its activities beautifully coordinated. Form and function are wonderfully matched.

Extension

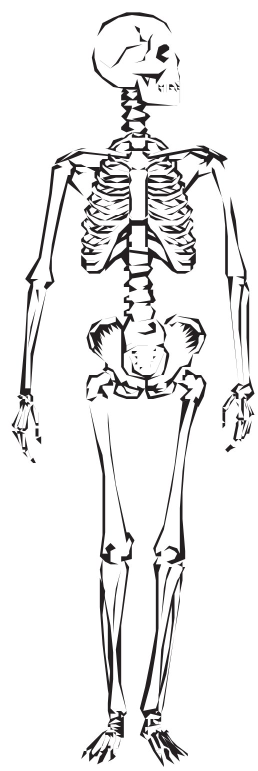
Experiment with different sizes of note cards, different materials for the cylinder, different cylinder diameters and differing numbers of books.

References

Allison, Linda. *Blood and Guts: A Working Guide to Your Insides*. Boston: Little, Brown, 1976.

AU & HJ

“*Form matches function*”



9. My Heart is Racing: Modeling the Circulation of the Blood

Equipment Needed

Two different colored garbage bags, scissors, masking tape, three different colored markers (red, blue, and black), index cards, six sheets of paper ($8^1/_2$ x 11), the drawing of the circulation model found in this book

Purpose

To teach the route of blood through the heart and lungs

Safety—Special Considerations

Avoid using masking tape on any surface that may be damaged by the tape. Masking tape tends to set with time and can become difficult to remove. If this activity is done outside, colored chalk could be used instead of garbage bags and tape.

Grade Level—Time Needed

Grades 3-6; Time: students can make the model in about 30 minutes. The whole activity should take about 50 minutes.

Background

The path of blood passing through the heart and lungs can be very confusing for students when they look at a drawing of the heart. The opportunity to see and act as a part of the circulatory and respiratory systems should increase their understanding of the movement of the blood. Emphasize the fact that God located the heart in a very safe place, centrally located between the lungs and protected by the ribs and sternum. The heart is a double pump. The right side pumps blood to the lungs and back to the left side. The left side pumps the blood to the entire body.

The names of the basic parts of the respiratory and circulatory systems should be introduced before undertaking this activity. The flow of blood is as follows.

Blood from the body enters the right atrium, Next it is pumped to the right ventricle. Then the right ventricle pumps it to the lungs. Here in the capillaries of the lungs it picks up oxygen and releases carbon dioxide. Next it flows back to the heart and enters the left atrium. The atrium pumps it to the left ventricle. The term atrium refers to an entryway or a courtyard that one would enter first. Ventricle means a little cavity or a vent. The left ventricle is very strong and makes us think that our heart is on the left side of our body because we often feel its action when we work hard. We could even say that we pledge allegiance to the flag with our left ventricle. The left ventricle sends the blood out into the aorta (the largest artery). Next the blood branches out in many directions into the smaller arteries. Then the blood flows to the smallest arteries called arterioles and finally into nets of capillaries, each of which is only one blood cell wide. Here the liquid part of the blood can leave the blood vessels. Here oxygen is given to the cells and carbon dioxide is picked up by the plasma. Then the plasma returns to the capillaries. It also is picked up by the lymph vessels (a second way back to the heart). The blood in the capillaries then heads into the smallest veins called venules. Next the blood moves to the veins and finally to the largest vein, the vena cava. Valves in the veins prevent back flow and help to get the blood back to the heart. The vena cava empties into the right atrium.

Students are likely to ask about the color of blood. Red blood cells (RBCs) with lots of oxygen are bright red. RBC's with less oxygen are dark red which looks blue as we see it through our pigmented skin. In drawings it is customary to color the arteries red and the veins blue to reflect the oxygen content.

Blood is roughly 50% cells and 50% fluid (plasma). RBC's have a life of about 120 days. They are constantly being replaced by the red bone marrow found in the spongy areas of long bones such as the femur, and the flat bones of the ribs, breastbone, vertebrae and skull. Ask your students if they have ever made a million of something. Yes, they have. RBCs form at the rate of about 3 million per second. A single drop of blood has more than 250 million red blood cells in it.

The location for setting up this activity will depend on the availability of space. The authors placed theirs outside on a large concrete sidewalk. The diagram provided with this lesson shows what the system would look like if the person were facing the observer.

Procedure

Following the drawing in this book, have students construct the areas for the lungs and the four chambers of the heart with the masking tape. Label these areas. Place the cards representing valves in the appropriate places. Place the numbers of different labeled locations in the appropriate places. Cut the garbage bags into one-inch-wide strips. Tape the strips down to form the path that the blood would follow. Change the color of the garbage bag trail to reflect whether the blood has oxygen or not.

Assignment

Make a diagram showing the flow of blood through the respiratory and circulatory systems. Color the system to show oxygen content.

Christian Application

God has provided us with a very efficient way to reuse the blood in our bodies. This remarkable fluid is cleaned by the kidneys and has new cells and materials constantly added to it by other parts of the body. The heart may pump more than 105,000 beats per day. Each beat in an adult can pump out about five ounces of blood. This adds up to about 1800 gallons a day. God's excellent design allows the blood to go around and around. A single red blood cell could make 300,000 trips around the body before wearing out.

Extension

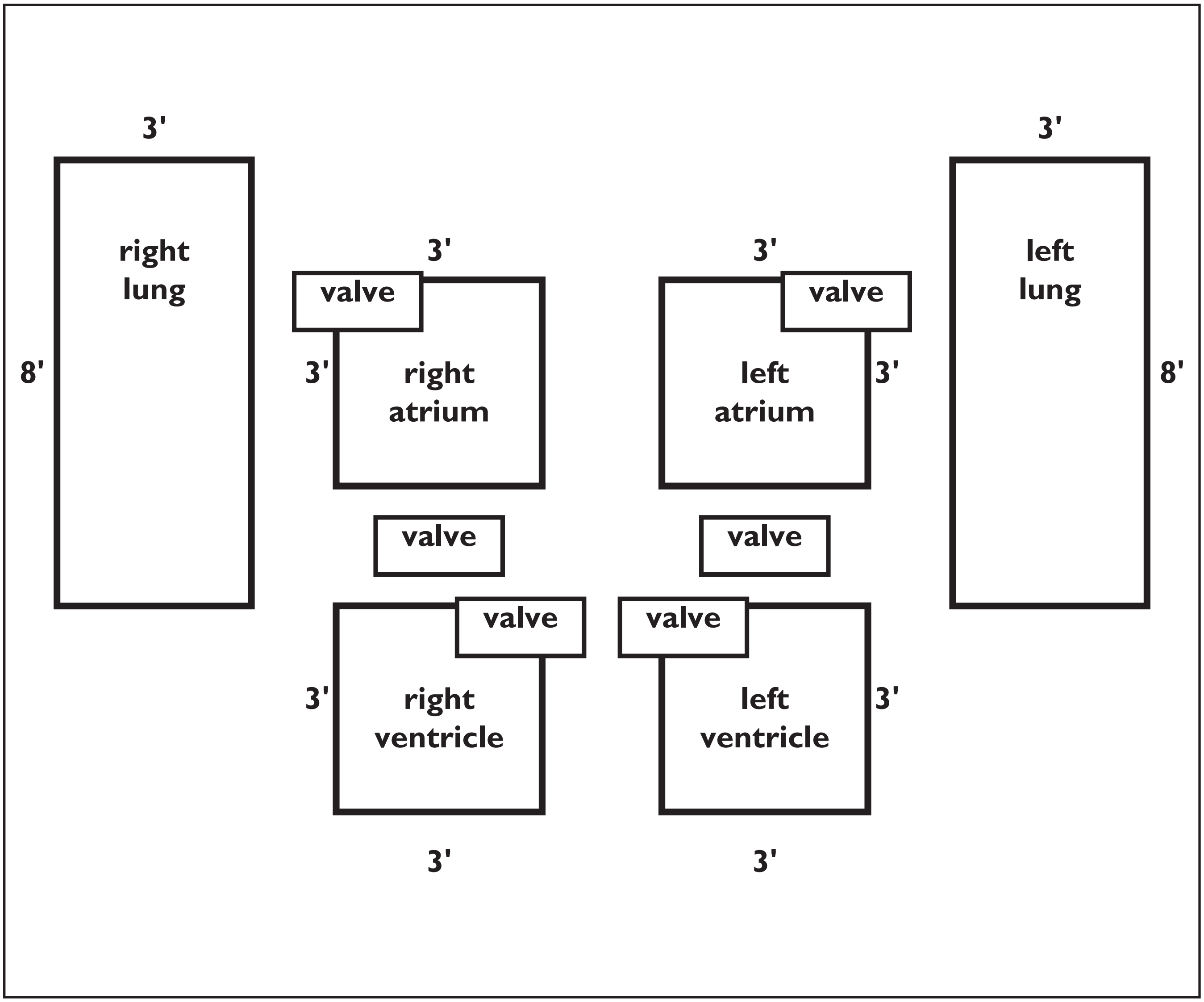
- The circulation model could be expanded to include alternate pathways to various parts of the body.
- Students could pass through the systems at different rates demonstrating the speed of blood while the body is sleeping, eating, hopping, or running.
- Music could be used to determine the speed that the student moves through the systems.
- Students could carry pieces of red paper (representing oxygen) while passing from the lungs through the left atrium and left ventricle down to the feet. They could leave the red paper with a student who could represent a cell living in the capillaries. Then they could go back to the heart and the lungs where they could pick up a new red piece of paper.

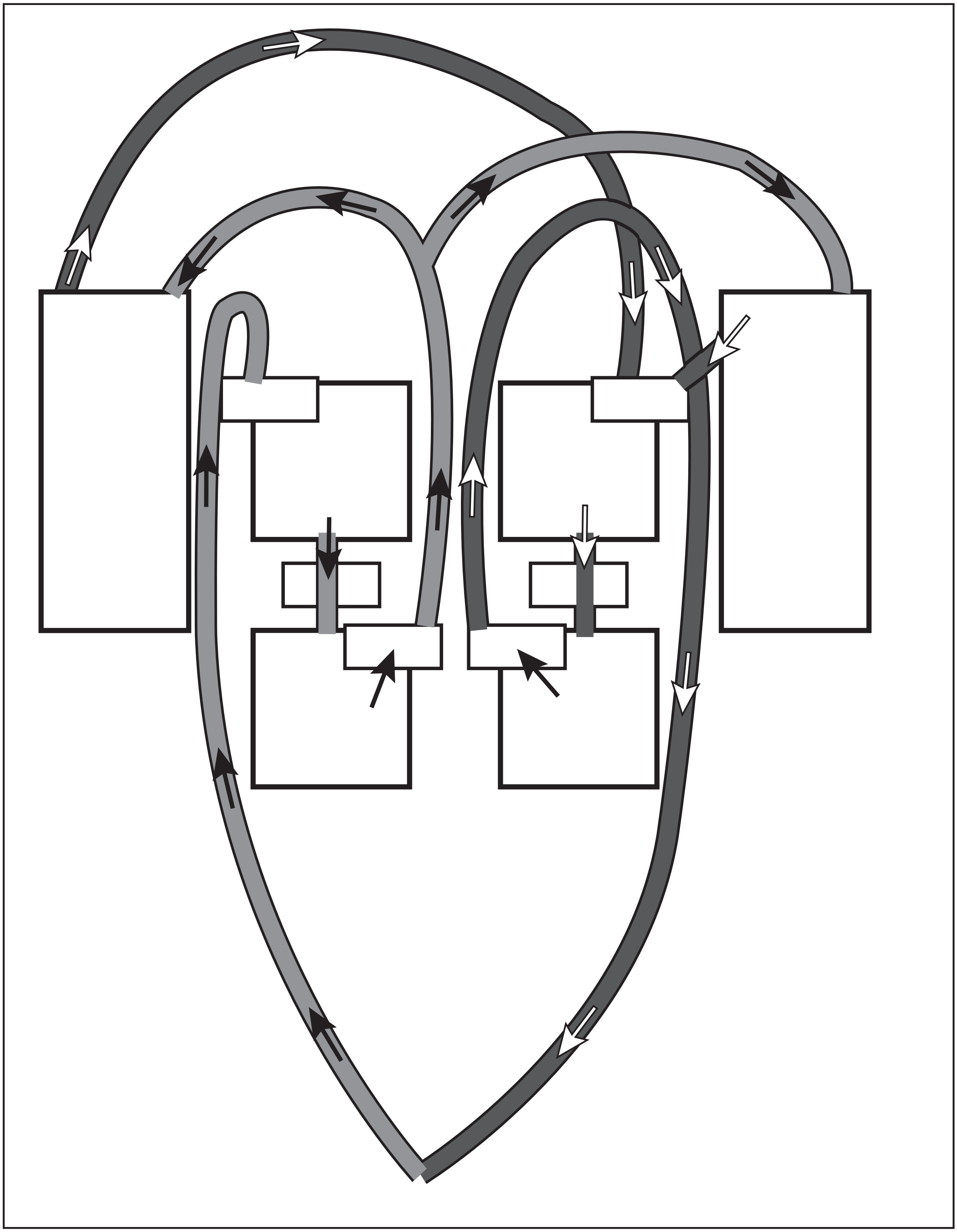
References

Guinness, Alma E. *ABC's of the Human Body.* Pleasantville, New York: The Reader's Digest Association, 1987, pages 88-111.

HJ

My Heart is Racing: Heart Model #1





10. Observation of the Circulation of the Blood

Equipment Needed

Equipment needed: Compound microscope, paper towels, fish net, gold fish

Purpose

To see how blood moves through the body
To see that the smallest blood vessels, the capillaries, are about as large as a single red blood cell

Safety—Special Considerations

To avoid bacteria students should wash their hands when this lab is completed. Remind them that the most common way in which germs are spread is by the hands. Our hands tend to place germs on the eyes, nose,and mouth area.

Do not keep a fish out of the water for more than ten minutes. Be sure to indicate that students should treat the fish with care and concern. God delights in all His creatures and is concerned for them. We are to use the creation for food and learning but at the same time should respect and not abuse it.

The smell of fish is not from the fish itself but comes from algae that grow on the fish.

Grade Level—Time Needed

Upper grades or high school biology classes; Time: one class period

Background

William Harvey (1578-1657) argued against Galen's theory of four separate body fluids and stated that blood must be circulating from the heart to the body and back to the heart again. He concluded this even though he could not see that the arterioles were actually connected to the venules. Only later were the connections called capillaries actually found by use of the microscope.

Procedure

Place a blank glass slide on the stage of your microscope to prevent water from getting on the condenser lens below the stage. Dip a paper towel in the same water from which the fish will be taken to control for environmental change. Capture a fish with the net. As soon as the fish is out of the water, a member of the team should note the time and keep the team aware of the ten-minute limit. Gently wrap the fish by placing it on the paper towel in your hand and quickly covering it with other parts of the towel. If the fish resists, be ready to cover it with your hand. Do not allow the fish to be injured by jumping out of your hand and falling to the floor. As you wrap the fish, allow its tail to remain outside the wrapping. Place the tail of the fish on the glass slide and focus the scope. You should see blood vessels in the tail. Arterioles (small arteries) will have blood cells moving toward the end of the tail and venules (small veins) will have blood moving back toward the body of the fish. Try to find capillaries that are about the size of a red blood cell. *Does the fish have a pulse that you can see?* (yes) Remember that directions are reversed by the microscope optics.

Assignment

Make a labeled drawing of what you see. Make a diagram of the pathway of blood through a person.

Christian Application

God has given us a wonderful circulatory system which furnishes our cells with oxygen and nutrients and removes carbon dioxide and wastes. This is one way in which He preserves us.

Extension

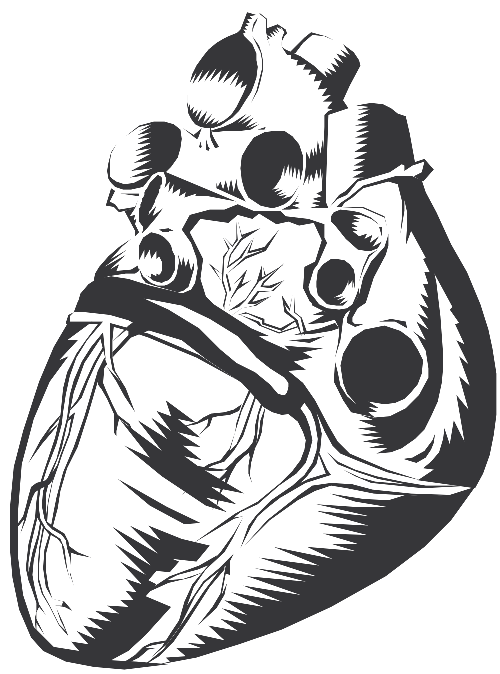
◆ Cells that are not directly located on blood vessels are nourished by the liquid part of the blood (plasma) which is able to leave the blood vessels and reach the cells. The plasma then returns to that vessel at an area of lower pressure (down the line) or is returned by the lymphatic system.

◆ Students might wish to study how blood flow varies with activity. They could learn to take and record their pulse after running, walking, resting, etc.

References

See articles in *World Book*: William Harvey and Blood (has illustration of capillaries)

PRB



11. Labels: The Ingestion Question—Am I Really What I Eat?

Equipment Needed

A copy of the "Food Guide Pyramid" (found on labels for food products such as cereal boxes and bread wrappers), nutritional information labels from various foods, and some examples of various foods.

Purpose

To teach students to read labels and recognize the ingredients in the canned and packaged foods
To increase awareness of the importance of careful eating

Safety—Special Considerations

None

Grade Level—Time Needed

Any grades; time: two class periods

Background

Many students have little understanding of the substances and quantities that are in the food they eat. This exercise will educate them about the ingredients in canned and boxed foods. The ability to read and understand food labels is a life skill which can be taught at any level. The teacher may want to collect labels from food products for special emphasis. Cereal and canned soup can be checked for sodium content, granola can be checked for fat content, and flavored yogurt can be checked for sugar.

Food labels will tell the students the number of calories in a serving. Calories are units of energy. The label will also state how many of the calories are from fat. Experts say that fat should not represent more than 30% of the calories in a person's diet. Unfortunately, the fat content correlates with the taste of food for most individuals.

Also listed will be the total fat, the saturated fat, the cholesterol, the sodium, the total carbohydrate, the dietary fiber, the amount of sugar and the amount of protein. Saturated fat and cholesterol are linked to heart disease. Sodium contributes to high blood pressure. Carbohydrates (including sugar) are used for energy but one can get too much. Fiber helps move food through the body in a shorter time; this is healthy for the intestines. Protein, generally in meat, is used by the by body for structure (muscles, collagen) and enzymes, but many Americans eat much more than they need.

In 1992 the United States Department of Agriculture (USDA) basically recommended that people eat more grains, fruits, and vegetables. USDA suggested cutting back on meat and dairy products. Fat and sugars should be consumed sparingly. To show these recommendations graphically the USDA published the "Food Guide Pyramid."

A young adult generally needs 2000 calories a day.

There is a list of substitutions recommended by Dr. Densie Webb in the side column that will lower the amount of fat intake. Students could be quizzed on these.

Substitutions

Instead of	Choose
Potato chips or nuts	Pretzels
Oil-popped popcorn	Hot-air popped popcorn
Doughnuts	English muffins or bagels
Cookies	Graham crackers or vanilla wafers
Bacon	Canadian bacon
Mayonnaise	Mustard or ketchup
Whole milk	Low-fat or skim milk
Granola	Plain whole-grain cereal
Butter and cream cheese	Fruit spreads or jam
Munster or cheddar cheese	Part-skim mozzarella
Ice cream	Non-fat frozen yogurt or sherbet
Oil-packed fish	Water-packed tuna or sardines

Procedure

Discuss the "Food Guide Pyramid" with the class. Ask student to name examples of foods that belong to each of the five groups. Show them how the pyramid works. *Which foods should they eat more than others* (bread, cereal, rice and pasta, the foundation of the pyramid)? *Which groups form the next layer* (vegetables and fruits)? *What foods are at the third layer* (dairy, meat, eggs, and nuts)? *What should be used sparingly* (fats, oils, and sweets)? Develop concepts of fats, carbohydrates and protein that depend on examples. Then have students collect labels from canned and boxed foods that have been used in their homes. (Schools with lunch programs might use the cafeteria as a resource.) The teacher should point out the type of data that is available on the labels and encourage the students to be ready to discuss what their labels say the foods contain.

The labels collected can be discussed and posted on the room bulletin board. Students can group labels according to their content. Have the students define the categories.

Assignment

Tally the total intake of any one ingredient (or more for older students) in canned and boxed food intake for a week. Older students can compare their intake with the recommended daily amount.

Christian Application

The body is the temple of the Holy Spirit. We are to care for our bodies. Watching what we eat is part of that stewardship.

Extension

Guides to the number of calories in food, such as The Barbara Kraus Calorie Counter are widely available. Guides to other nutrients are also available. Students could keep a tally of the calories they consume in a day or a week. Students should be made aware that the media often present unrealistic images of humans. Young women are often shown as thinner than good health allows. Such images may be dangerous if young women try to diet to attain them.

References

Kraus, Barbara. *The Barbara Kraus Calorie Counter: Thousands of Entries Giving the Caloric Content of Brand-Name and Basic Foods.* New York: Putnam (Perigee Books), 1985.

Webb, Densie. "Exploring the Food Guide Pyramid," *The World Book Health & Medical Annual 1994*. Chicago: World Book, pages 57-71.

AU and HJ

"*Many students have no understanding of the substances and quantities that are in the food they eat.*"

12. Fats: The Ingestion Question—Am I Really What I Eat?

Equipment Needed

Brown paper bags (either grocery or lunch bags will do), snack foods such as potato chips, cookies, peanuts, pretzels, cake, pie, chocolate chips, etc. The teacher should include peanut butter, butter, margarine, or any other high fat food.

Purpose

To help students recognize the varying amounts of fats in common snack foods
To promote moderation of fat consumption

Safety—Special Considerations

Do not accidentally place foods and paper bags on any surface (books, important papers) that could be damaged by grease or fat stains.

Grade Level—Time Needed

Any grade; Time: a 15-minute session to set up the experiment with the students, a 35-minute class period several hours later to analyze and discussion the results

Background

Even though the human body requires a certain amount of fat as a part of a normal diet, the consumption of more fat than the body can use will result in an increase in body mass. (Consumption of other foods in excess will cause an increase in fat.) The body needs about one tablespoon of polyunsaturated fat each day, yet most people consume six to eight times as much (Tapley, 294).

Some fats may also harm the circulatory system by causing cholesterol deposits in the arteries. Atherosclerosis [ahr - throw'- sklair - oh'- sis] is a thickening and loss of elasticity of the artery walls due to such deposits. Cholesterol is transported by fatty proteins in the blood called lipoproteins. Saturated fats (which are found in animals foods) in our diets are believed to raise the level of cholesterol in the blood. A diet that is high in saturated fats causes the liver to produce high levels of low density lipoproteins (LDLs). LDLs cause the levels of cholesterol in the blood to rise. Fats that are normally solid at room temperature are usually saturated fats. There are two exceptions: coconut oil and palm oil which are unsaturated. The opposite type is the high density lipoprotein (HDL) which can actually remove cholesterol from the artery walls and take it to the liver where it is safely stored or excreted. Polyunsaturated fats come from poultry, fish, and vegetables. The subject of cholesterol is causing much debate among scientists and research in this area is continuing.

The fat that we eat also carries the fat-soluble vitamins (A,D,E, & K) into our bodies which stores them in our body fat.

Students need to have a moderate intake of fats. The most difficult concepts to teach are those involving moderation. The teacher must guard against reinforcing images of unhealthy, ultra-thin women promoted by American society. Such images may cause students to attempt unrealistic diets leading to anorexic behavior.

Procedure

Have the students place a sample of each food on the brown paper. Spots on the brown paper may be caused by oils on the skin. Let the samples stand one to three hours. Discard the food samples while labeling the stains produced by each food. Observe fat stains, discuss, and eat food, if desired. Upper grade students may wish to monitor other foods to note the fat content or the lack of fat. Surfaces of fresh foods (non-processed) such as a peeled boiled egg or a lettuce leaf, can be dried off so as not to leave large water stains that may be falsely interpreted as fat. Tell students to allow time for the translucent stain on the paper to dry. If the stain evaporates, the item does not contain fat or oil.

Assignment

During the coming week, students should choose a meal or two and place a portion of each food served during that meal on a piece of brown paper bag. Students should write a paragraph reporting on what they find and reflecting on the amount of fat in their diet.

Christian Application

Christians have a responsibility to be good stewards of their bodies. People tend to eat too much fat. Although fats in moderation are no danger to the body, a Christian is encouraged to eat a variety of foods and to exercise to insure that extra fat will not be stored in his body.

Extension

Students may wish to study more about fats. Some fats are safer than others. Students could create a bulletin board of good and bad fats.

References

Guinness, Alma E. *ABC's of the Human Body*. Pleasantville, New York: The Reader's Digest Association, 1987, page 253.
Heimler, Charles H. *Focus on Life Science*. Columbus: Merrill, 1984.
Tapley, Donald F. et al. *Complete Home Medical Guide*. New York: Crown, 1985.

AU and HJ

“*The most difficult concepts to teach are those involving moderation.*”

13. Starch: The Ingestion Question—Am I Really What I Eat?

Equipment Needed

Iodine solution, dropper, white bread, corn starch, cooked egg white, potato, rice, cereals, lima beans, other foods of choice, and a knife or scalpel

Purpose

To identify foods with starch, a life skill for the student attempting to maintain a healthy diet

Safety—Special Considerations

The iodine solution must be handled with care. Iodine is poisonous; it will also stain clothes and skin. Sodium thiosulfate will bleach iodine stains on clothing and table tops. Stains on skin will wear off. Iodine was once widely used in households to kill bacteria on open wounds. It has been replaced by less painful antiseptics. Iodine is a standard test for the presence of starches in food, but precautions need to be taken. Warn the students not to eat any of the foods on which they have placed iodine. The teacher may also wish to do the cutting with the scalpel or knife depending on the age of the students.

Grade Level—Time Needed

Any grade; Time: one class period

Background

Foods containing starch are part of the group of foods called carbohydrates. Starches are long chains of sugar molecules. They are good sources of energy. Carbohydrates may be stored as supplies of reserve energy in our liver or in our muscles. The long molecules, when dried and tangled together, can make shirts and paper stiff. Plants store the extra sugar that they make in photosynthesis as starch.

Iodine solution is used to test for starch. When it is added to starch, a chemical reaction turns the solution from brownish-red to blue-black.

Procedure

Ask the students if they think that bread contains starch. (It does.) Put three drops of iodine solution on the bread. Tell them that if the red iodine turns blue-black, there is starch present. If there is no color change, there is no starch. Chemists often depend on color changes to determine that something has happened. Have the students observe whether the bread contains starch. Have the students repeat this same test with other foods including corn starch, cooked egg white, potato, rice, cereals, and lima beans. Make a chart recording your prediction and the results.

Equipment Needed

Have the students complete the chart that compares their results with their predictions. Teach the students how to set up a clear chart with headings, divisions, and a consistent style of lettering. Examine charts found in books.

Christian Application

Christians have a responsibility to be good stewards of their bodies. A Christian is encouraged to eat a variety of foods and to exercise to make use of the energy starches provide.

Extension

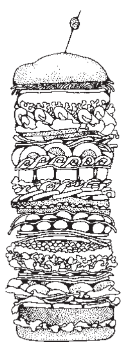
Test other types of bread and other foods of choice. Check various types of paper. (Stiff paper often has added starch.)

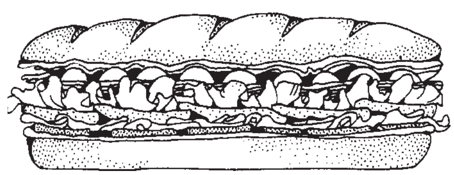
References

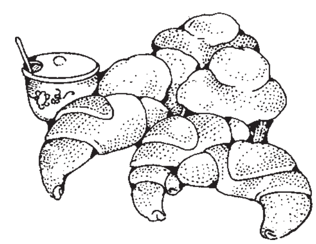
Devito, Alfred. and Gerald H. Krockover. *Creative Sciencing: Ideas and Activities for Teachers and Children.* Boston: Little, Brown, 1980, pages 168-9.

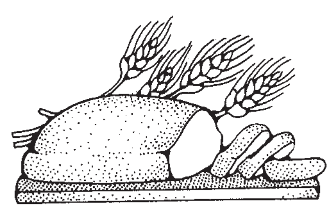
Heimler, Charles H. *Focus on Life Science.* Columbus: Merrill, 1984.

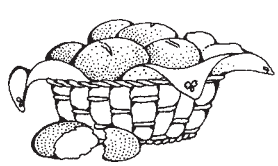
AU and HJ











14. “Don’t Blow It!” Exhaust

Equipment Needed

Plastic bags

Purpose

To see that the gases they inhale are different from those they exhale

Safety—Special Considerations

Students with any respiratory problems should not do this activity.

Grade Level—Time Needed

Any grade; Time: about 15 minutes

Background

Air is a mixture of gases. Normally it consists of about 79% nitrogen, 21% oxygen and less than 1% carbon dioxide, water vapor, and other gases. When air is inhaled and exhaled the body takes out some of the oxygen and adds carbon dioxide. This is called gas exchange. The body also warms the air and adds moisture.

Interestingly, the brain stem monitors the level of carbon dioxide in the blood. This serves the body well, because if the carbon dioxide level is down, the oxygen is up; and vice versa.

Carbon dioxide is not a poison like carbon monoxide, but lack of oxygen is a matter of life or death.

Procedure

Allow a student to do this experiment only once. Ask for volunteers. Tell them all the directions before beginning. (1) Students should take a small flat plastic bag and breathe into it once. (2) Next they should form a snug seal over their nose and mouth with their hands and count how many times they can inhale the same breath before it becomes uncomfortable. (3) The students should stop immediately when they feel uncomfortable. (4) Discuss why this happened. (The oxygen is not all used up by one breath. Nevertheless, each breath uses more and more of it until the blood in the lungs cannot get enough. This type of breathing also puts more and more carbon dioxide into the bag. The re-breathing of the same air causes more and more carbon dioxide to build up in the lungs and blood. When the brain stem senses the increase in carbon dioxide in the blood, it signals the diaphragm to increase the breathing rate and the heart to increase the pulse rate to try to get rid of it. Ask if the students noticed this.)

Students should observe and record what happens.

Equipment Needed

Yawns are believed to occur when the brain signals that it has too much carbon dioxide and so needs more oxygen. Yawns seem to be part of breaking a slow breathing rhythm. Furthermore, many humans will unconsciously yawn when they see another person yawn. Have the students try an experiment. They should fake yawns in front of people who do not know about the assignment and record if they yawn or not.

Family Involvement

Share the results of the yawn experiment with your family.

Christian Application

God has created the human body so that the lungs can receive the oxygen that the body needs and expel the carbon dioxide that is building up in the blood.

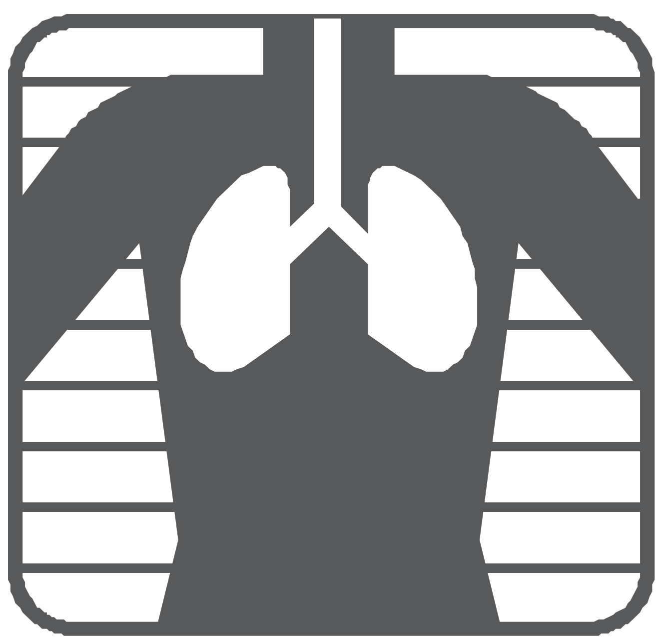
Extension

The teacher could make some carbon dioxide by mixing baking soda with vinegar in a container and then putting a burning match into the container. The match will go out. Students could make carbon dioxide with baking soda and vinegar and see if they can pour it from one container to another without loosing very much.

References

Allison, Linda. *Blood and Guts: A Working Guide To Your Own Insides.* Boston: Little, Brown, 1976.

HJ and AU



15. “Don’t Blow It!” Lung Model

Equipment Needed

Transparent glass or plastic two liter bottle with a lid, a plastic straw, scissors or a box cutter, clay or wax, a small balloon, a larger balloon or punching ball, a rubber band, a second larger rubber band

Purpose

To show the relationship between the diaphragm and one lung within the body

Safety—Special Considerations

When cutting off the bottle’s bottom, care should be taken to cut low enough to insure support of the outer walls of the bottle. The rubber from a punching ball, because of its thicker nature, makes a better diaphragm for the model.

Grade Level—Time Needed

Any grade; Time: one class period

Background

Many people do not understand the way the diaphragm and the lungs work. The lungs have no muscles that directly work them. The diaphragm is the main muscle that causes breathing. This model will help the students see this relationship better. The diaphragm is an involuntary muscle which divides the body in half. If a person is hit hard in the stomach, the diaphragm may be suddenly pushed into a position in which the muscle is temporarily paralyzed. A person “cannot get his breath” until the diaphragm muscle recovers and begins to work again. Hiccups are caused by spasms in the diaphragm.

This model does not show how the rib muscles also help the diaphragm muscle. Rib muscles raise the ribs when a person inhales and also increase the size of the chest cavity. The action of the moving ribs can be modeled with the handle on a water bucket. When the bucket handle is down, a person is exhaling; when it is up, the person in inhaling. “Breathing is a process in which the ribs and diaphragm alternately increase and decrease the size of the chest cavity” (Heimler).

Procedure

Punch a hole in the bottle lid. Insert the plastic straw. Seal the area around the hole and the straw with clay or wax so that it is airtight. Secure the small balloon tightly to the end of the plastic straw with a rubber band. Cut the bottom off the bottle. Stretch the larger balloon tightly across the bottom of the bottle and secure it with the larger rubber band. (See Diagram) Gently push the bottom balloon (diaphragm) up into the bottle. Observe the small balloon and feel the air rush out. Allow the diaphragm to relax and watch the small balloon (lung) fill. Continue to contract and relax the diaphragm.

Equipment Needed

Check your own diaphragm. *Why can’t you exhale when you close your nose and mouth?* Using reference materials, find out if the lungs are like balloons. *In what ways is this true?* (They expand and contract.) *How are they different?* (There are many small openings inside the lungs which are called alveoli. The lungs looks like Styrofoam inside.)

Christian Application

God gives us the ability to breathe without having to think about taking each breath. We are fearfully and wonderfully made and maintained.

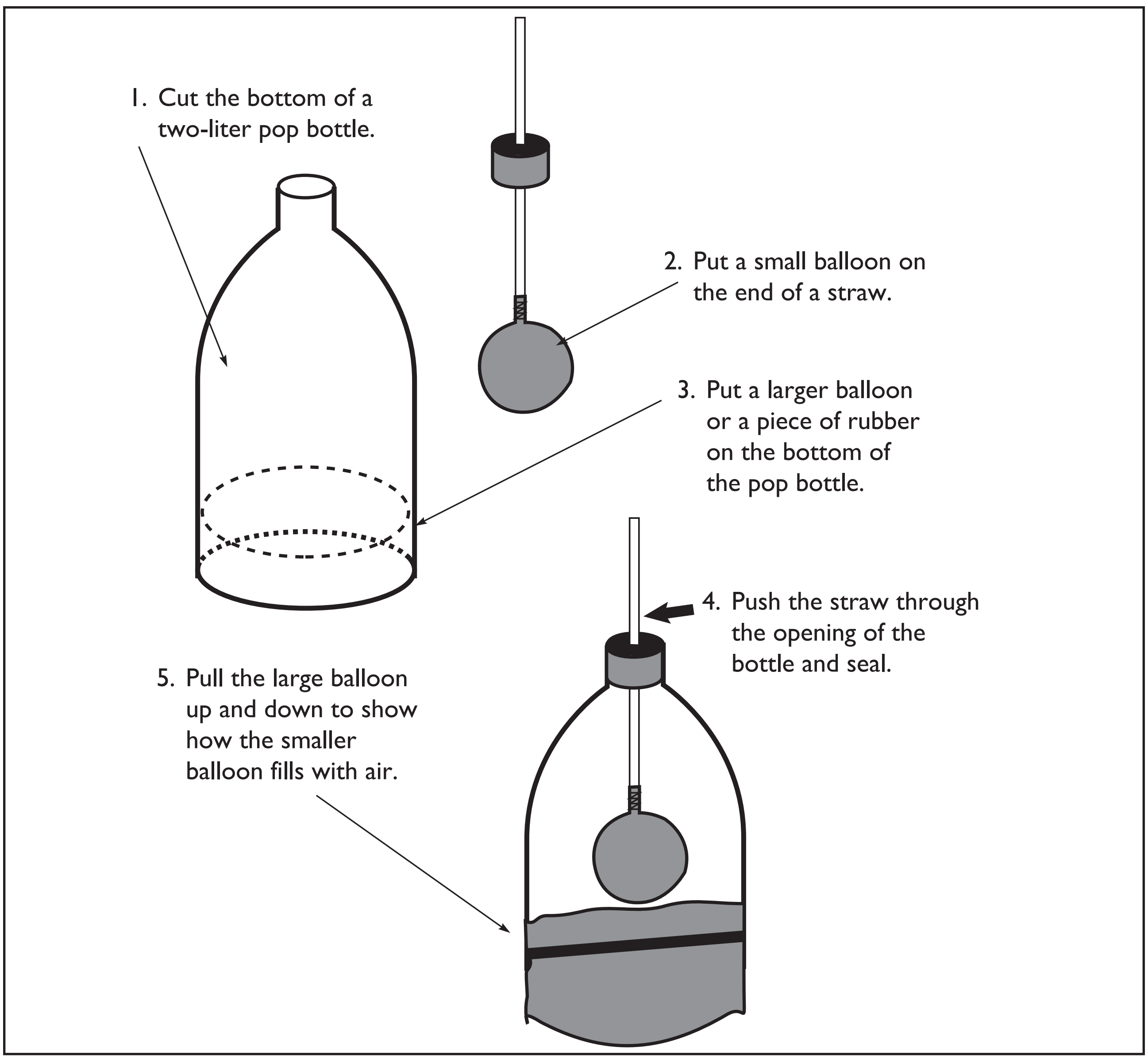
Extension

This model could be built using two small balloons and a "Y" tube to represent human lungs more closely.

References

Allison, Linda. *Blood and Guts, A Working Guide to Your Own Inside.* Boston: Little, Brown, 1976.
Heimler, Charles H., *Focus on Life Science.* Columbus: Merrill, 1984.

AU & HJ



16. Lung Capacity

Equipment Needed

Plastic dish pan, small mouth gallon jug, measuring cup, permanent marker, ruler or straight edge, flexible plastic drinking straws or a length of rubber tubing, Isopropyl (rubbing) alcohol, cotton balls, masking tape, food coloring These materials are sufficient for a class demonstration.

Purpose

To demonstrate the capacity of a person's lungs

Safety—Special Considerations

This activity requires a water supply and an area where a potential water mess won't be a problem. The gallon jug needs to be refilled for each demonstration. Since multiple students may blow through the same tubing or straw during this demonstration, students should remember to cleanse the end of the tubing or straw with alcohol and a cotton ball. The end of the tubing or straw opening must remain inside the jug to test a breath. Remember to empty the plastic dish pan after a few trials or it may overflow during a trial.

Grade Level—Time Needed

Any grade, goes over well with adolescent boys; Time: one to two class periods

Background

A person's breath may be referred to as his spirit. The English language has words like "inspire," "perspire," "respire," and "expire." All of these may have something to do with breath. A spirometer (spuh - rah'- muh - ter) is a way to measure a person's breath or lung capacity. Our life depends directly on the ability of our lungs to take in and use the air and oxygen that we need. The more air and oxygen we take in and use, the easier activities of everyday life will become. A person's lung capacity should increase as the lungs grow. Smoking cigarettes is hazardous for many reasons. One of these is that it greatly decreases lung capacity.

A normal breath is shallow and uses only about 50% of the total lung capacity.

Procedure

Predict who in the class may have the greatest lung capacity. Assemble the set-up as shown in the diagram. (1) Tape a piece of masking tape vertically to the side of the jug as shown. Calibrate the tape by pouring colored water into the jug. Some measuring cups have metric units. One-fourth cup equals 60 milliliters. Start calibrating from the bottom of the jug, making marks at reasonable intervals on the tape. (2) Completely fill the jug with colored water. Have a partner help cover the jug's opening with one hand and flip it upside down into a dish pan of water. If air gets into the jar, try again. (3) Select one student to test his lung capacity. The student should test a normal breath by exhaling into the tubing or straw. Observe and record the results. Have the same student run in place for one minute. Observe and record the results. (To increase time efficiency during this lesson, develop a rotation of students using the apparatus or have several set-ups.) (4) Each time a different student is measured be sure to place the hose into alcohol and then rinse with clean water. Continue until all students have had a chance to test their lung capacity.

Athletic eighth-graders may be able to empty a gallon. A second jug can be ready to go and the hose can be quickly switched.

Assignment

Using a bar graph, compare and contrast the lung capacities of one grade with those of another. Collect and record each individual's lung capacity to determine a mean (average) for the grade.

A math assignment could be to calculate the total amount of air that is brought into the lungs in one hour, one school day.... The students would first have to ask themselves what they would have to know to be able to calculate the answer.

Christian Application

Lung capacity can become enhanced as we exercise and care for the "temples" (bodies) God has given us. Exercising is part of good stewardship of the body. Students have different gifts and this exercise can be an good opportunity to compliment athletic students who may not always do so well in other activities.

Extension

Have a contest to see who can blow up the biggest balloon with just one breath.

References

Allison, Linda. *Blood and Guts—A Working Guide To Your Own Insides*. Little, Brown, 1976.

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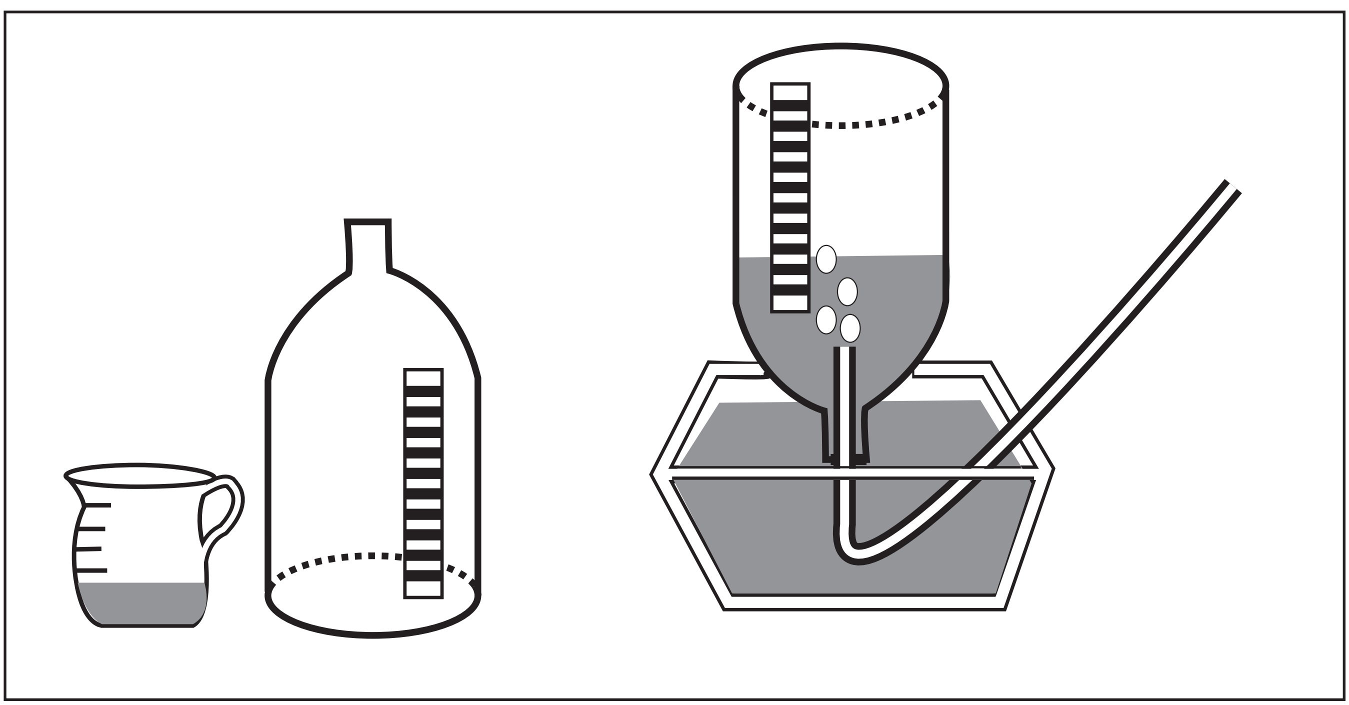

17. The Need for Saliva in the Taste Process

Equipment Needed

Dry paper towels, soda crackers (one of each of these for each student).

Purpose

To see how saliva is necessary for taste

Safety—Special Considerations

Students should have clean hands. Crackers and paper towels should be kept clean.

Grade Level—Time Needed

Grades K-3; Time: about ten minutes

Background

We need saliva to taste food because the chemicals in the food need to be dissolved and sometimes need to broken down. Both are true in this activity. At the tip of the tongue we taste sweet things. Salt is tasted all over the tongue including the tip. Sour is on the sides; bitter is at the back. Crackers are not sweet because they are made of long molecules called starch. Starch is actually composed of a chain of sugars. The saliva has enzymes in it which break the starch into separate sugar molecules. These can be tasted by the tip of the tongue. The salt merely needs to be dissolved to be tasted by the tip of the tongue.

Ackerman has written a very good book on the senses for the lay person. We have four basic taste receptors on the tongue. Most of what we call taste also involves our sense of smell. We often complain that we cannot taste anything when we have a cold and our noses are filled with mucus. We have many more kinds of molecule receptors in our noses than on our tongues.

Procedure

Have the students wash their hands. Each should select a paper towel and cracker. Have the students dry the tip of the tongue with the paper towel. Then they should touch their crackers to the tips of their tongues. They will not be able to taste the crackers if the tips of the tongues are dry. After their mouths are moistened again, touch the crackers on the tips again. Ask the students to identify the taste(s) (salty, possibly sweet).

Christian Application

God has given us a wonderful system to let us be able to enjoy the taste of food.

Extension

To see the difference between dry foods (crackers, cereal, cookies, etc.) and moist foods (fruits), select some children's books to read. Suggestions are: Pluckrose's *Think About Tasting* and Ziefert's *What Do I Taste?*

References

Ackerman, Diane. *A Natural History of the Senses*. New York: Random House, 1990.
Pluckrose, Henry. *Think About Tasting*. Milwaukee: Gareth Stevens, 1995.
Ziefert, Harriet and Mavis Smith. *What Do I Taste?* New York: Bantam, 1988.

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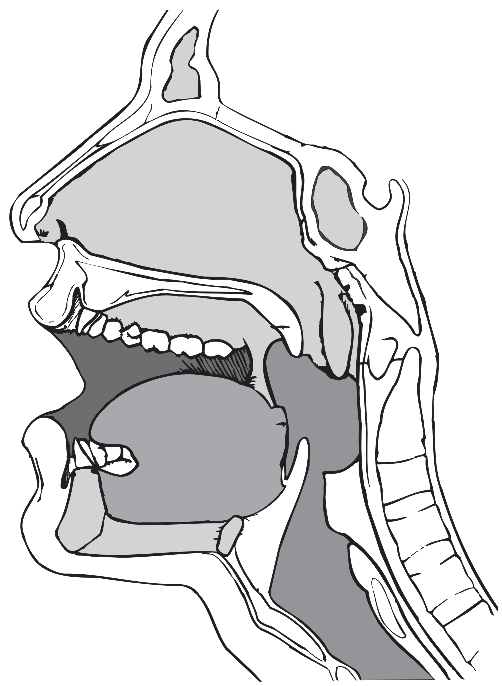

18. Areas of Taste on the Tongue

Equipment Needed

Label at least four individual cups of sugar water, salt water, instant coffee mixed in water (bitter), lemon juice in water (sour). These are the supply cups. Put a different color dot on each. Have one cup of water for each student, one empty cup for each student, cotton swabs, a drawing of the tongue.

Purpose

To find the areas for the sweet, salty, bitter, and sour receptors on the tongue

Safety—Special Considerations

Students should have clean hands. They should wash them again if they touch a person's mouth. They should be cautioned to touch tongues gently and not so far back that it causes a person to gag. A cotton swab that has been in someone's mouth (or contaminated in any other way) should not be returned to any of the four supply cups. A swab used in one person's mouth should not be used in another person's mouth. If a student needs more of a particular chemical, a new cotton swab should be taken.

Grade Level—Time Needed

Grades 1-3; Time: about 20 minutes.

Background

At the tip of the tongue we taste sweet things. Salt is generally tasted all over the tongue, especially the edges, and this includes the tip. Sour receptors are found on the sides of the tongue; bitter receptors are at the back. Do not expect everyone to be the same; individual differences exist. Let the student discover this.

The signal generated on the tongue travels to the brain for interpretation. The sensation we feel is actually in our brain. Taste is highly individual. Saliva even has different tastes. Part of the explanation is heredity. Our sense of smell is also involved in taste.

Procedure

Tell the students that this activity will test the tongue for the relative presence of its four different taste receptors. These are the four primary tastes. Divide the students into teams of two or three. Have one student on a team dip a swab into one cup and touch it to different areas on the other's tongue. The person being tested should report the strength of the taste. A colored spot (that agrees with the spot on the supply cup) should be placed on the picture of the tongue in the area where the taste was strongest. Proceed until all four taste areas have been located. Rinse mouth with water between the testing of the different solutions and put the rinse into an empty cup. Partners switch. When all are done, compare to see which areas taste sweet, salty, bitter, and sour.

Assignment

Color the areas on the drawing of the tongue using the same colors as the dots designated for that taste, and label that area. Find pictures of foods which have those tastes, glue on paper, draw a line to that colored area.

Christian Application

Marvel at the different foods God has provided us and how we can distinguish them with such a small organ and only four general areas.

Extension

For a few days be aware of the foods eaten at lunchtime and the classifications into which they would fall. Select a children's book to read. Some suggestions are: Aliki's *My Five Senses* and Ziefert's *What Do I Taste?*

References

Aliki (Leacouras Brandenberg). *My Five Senses*. New York: Crowell, 1962.
Ziefert, Harriet and Mavis Smith. *What Do I Taste?* New York: Bantam, 1988.

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What are Facts?

"Too often students unquestionably accept things they read or hear as facts. It is an accepted fact that the center of the Earth is composed of molten lava—or is it? It is an accepted fact that the planet Pluto is extremely cold—or is it? Has anyone ever been to the center of the Earth or to Pluto?

"...scientists often cannot get first-hand information about a phenomenon. Many scientific facts are gotten from hypotheses, observations, and experimentation: such are the workings of science."

Keith Koyama ("What Are Facts?" *The American Biology Teacher*. March 1975, pp 178 - 179.)

19. Do You Really Need Two Ears?

Equipment Needed

A piece of cotton for each student, an alarm clock or scissors

Purpose

To see why two ears give a person more information than one

Safety—Special Considerations

Don't put cotton into the ear too far. Allow some to protrude for easy removal.

Grade Level—Time Needed

Grades K-2; Time: one class period

Background

Any sound that has to travel different distances will hit the closer ear a fraction of a second before hitting the other ear. Also the ear that is closer to the sound will sense it as being a bit louder. If a sound is directly in front or in back of us, the sound will arrive at both ears at the same time. If we have no further information, we assume that the sound is in front of us.

Our ears are very sensitive. Loud sounds can damage them. Babies have the most sensitive ears. They recognize their mother's voices, remembering them from before they were born. If our ears were more sensitive, we would hear the motion of the molecules. Dogs and gerbils can hear high-frequency sounds above the human hearing range. Elephants (big ear drums) can communicate with low-pitched sounds that we cannot hear.

Procedure

- ◆ Ask the student to close both eyes. Sound an alarm clock or strike a scissors on metal somewhere in the room and have the student point to the direction from which the sound is coming. Record the number of correct locations on the board.
- ◆ Next, have the same student place cotton in one ear. Tell the student to allow the cotton to protrude. Again, with eyes closed, students should point to the direction from which the sound is coming. Record the number of correct locations.
- ◆ Repeat with all students. Compare the data from using one ear to the data from using two ears.

Assignment

List other things which could be used to make the tapping or clicking sound.

Christian Application

By giving us two ears, God has made us more able to be aware of our surroundings. We can enjoy pleasing sounds more fully, and we become aware of the direction of possible danger sooner. We are fearfully and wonderfully made.

Extension

Use some of the items the students listed on the assignment lists to see which objects produce sounds that are easier to recognize with one ear. Select books to read to the students such as Margaret Wise Brown's *Noisy Book*; Bill Martin's *Polar Bear, Polar Bear, What Do You Hear?*; or Maria Rius' *The Five Senses: Hearing*.

References

Brown, Margaret Wise. *Noisy Book*. New York: W.R. Scott, 1939.
Martin, Bill. Jr. *Polar Bear, Polar Bear, What Do You Hear?* New York: Henry Holt, 1991.
Rius, Maria. *The Five Senses: Hearing*. New York: Barrons, 1985.

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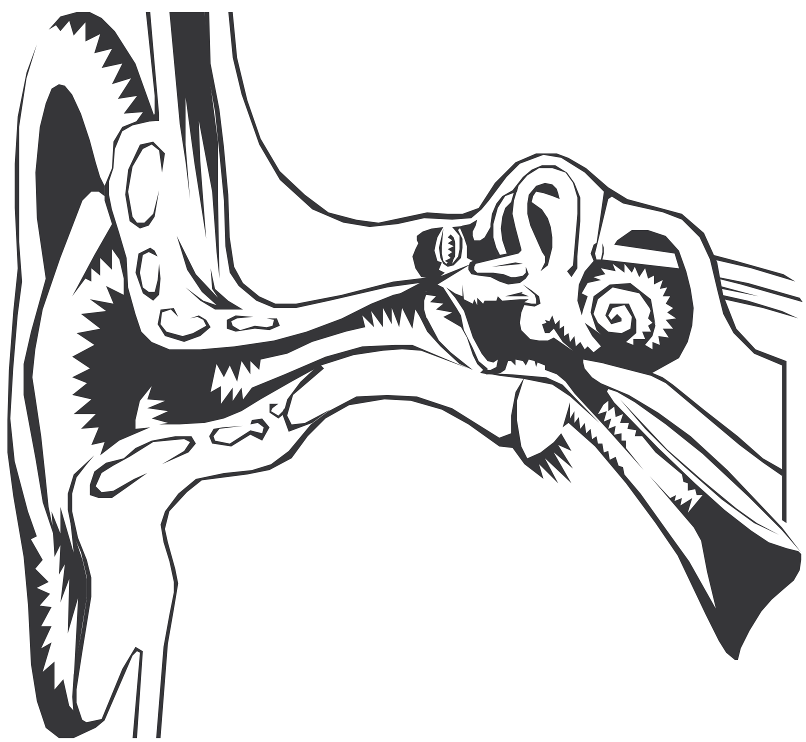

20. Observation of the Sensitivity to Touch on the Skin

Equipment Needed

Tape sharpened pencils in various combinations:
(1) two taped together with the points next to each other
(2) three taped together with the points in a row, and
(3) two taped together with one inverted so that a point and an eraser are on one end. Have a set for each team of students.

Purpose

To find that different areas of our skin vary in sensitivity to touch

Safety—Special Considerations

Caution the students to use only a slight touch when using the pencils so that no pencil is poked through the skin. Students can be told that they should never poke someone with a pencil because of danger of infection and the chance of leaving graphite (pencil lead) below the epidermis, which could mark a person permanently.

Grade Level—Time Needed

Grades 1-3; Time: about fifteen minutes depending on class size.

Background

The number of touch receptors in any part of the body varies.

Procedure

Tell the students that they are going to test various areas of the skin for sensitivity. Use the following areas to test: fingertip, neck, cheek, inside of elbow, wrist, and palm. Small groups should be formed. Have one student cover both eyes while a partner gently *touches* one of the different pencil setups to the given area. Randomly use each of the pencil combinations on an area three times. The student being tested should tell how many points he or she feels (if the eraser is used, that counts as none). For older students a chart could be made. Label the area of skin being tested and the number of correct responses. Reverse partners. Decide which areas were more sensitive.

Assignment

Older students could graph the correct answers and compare with the other groups to make a class graph.

Christian Application

God has given us sensitive areas on our skin to keep us safe from harm. We should be careful with our own and others' bodies.

Extension

For a few days observe for incidents where we or others were helped because a sensitive area helped to protect us. Observe if other areas could be included as sensitive areas of skin. Select a children's book to read to the class. Some suggestions: Aliki's *My Hands,* Aliki's *My Five Senses,* and Brown, Marcia *Touch Will Tell*.

References

Aliki (Leacouras Brandenberg). *My Hands*. New York: Crowell, 1962.
Aliki (Leacouras Brandenberg). *My Five Senses*. New York: Crowell, 1962.
Brown, Marcia. *Touch Will Tell*. New York, Watts, 1979.

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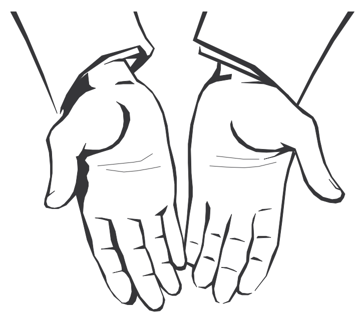

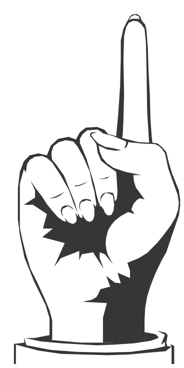

21. Observation of the Colors of the Rainbow

Equipment Needed

Slide projector (overhead projector or plain light bulb will not work), spray bottle filled with water, room which can be very dark, high shelf or book shelf at back of room (or at back of experiment), baking pan with about 1 inch of water

Purpose

To see what conditions are needed to produce a rainbow

Safety—Special Considerations

Do not spray at the projector light. Make sure the slide projector is solidly placed on a high shelf.

Grade Level—Time Needed

Grades K-6; Time depends on the number of students, one class period

Background

White light contains all of the colors. When the different wavelengths of light enter a different transparent medium at an angle, they will be refracted (bent from their path). Raindrops, prisms and other clear objects can produce such a separation of the colors. This occurs because longer wavelengths bend less than short ones. This separates the colors. From long to short wavelength they are red, orange, yellow, green, blue, indigo, and violet (ROYGBIV). Black is an absence of color.

Students may become confused if they have mixed pigments in art class. When pigments are mixed the results are subtractive instead of additive. For example, all the pigment colors added together made black because all colors end up being absorbed.

Were there rainbows before the flood? We do not know. If there were, they did not have the promise of God associated with them.

Procedure

Tell the students that they should be careful observers. Turn on slide projector. Darken room. Spray the water continuously. Stand so the water is sprayed between the light and the opposite wall. Students should be between the light and the mist (probably no more than three at a time) and should be able to see the colors of the rainbow. They will have to crouch or reposition themselves until they can see the colors. The bow will disappear if the mist stops or is in the wrong position.

To see a spectrum that can be studied longer, place a pan with about 1 inch of water on a wide window sill or on the floor in direct sunlight. Place a mirror in the water with the mirror leaning against the edge of the pan. Direct the reflected light onto a white surface (wall or paper). Play with this: turn the pan as necessary to form the spectrum. The results may vary with the time of day. Best results were observed when direct sunlight hit the pan in late afternoon. To get a good spectrum, you will have to move the pan around. A streak of white will often appear in the middle, so you can discuss the nature of white light. (White is a mixture of all colors.) Keep moving the pan until you get the best results possible at that time of day. The bow will move as the Earth turns. Repeat the making of the rainbow so that the students can look at it with a little more knowledge and appreciation of how it is formed. They should realize that water droplets in the air separate the colors of the sunlight (white light) to produce a rainbow. Have the students find and list the colors of the rainbow.

Assignment

Using the primary colors, with tempera paint or water colors, paint a rainbow in the proper sequence.

Family Involvement

A family can make rainbow toast. Have three saucers of milk. Put several drops of food coloring in each so you have red, yellow, and blue dishes. Using basting brushes, paint the colors of the rainbow on one side of the toast. Make sure the bread does not drip before putting it into the toaster. Note: send this home after using the art project so the students remember the sequence of colors and how to make the secondary colors.

Christian Application

Recall the promises God gave after the Flood and relate how God has kept them in our lives for which we can give thanks and praise. Realize how vast a rainbow is. God has made it so vast so many people can see it; yet each person sees it differently because each person is in a different place—it is personal. God also provides salvation for all yet each one receives it individually.

Extension

To understand that the colors are mixed to have light, make a five-inch circle, divide it into seven sections, and color or paint the colors of the rainbow in order. Poke a short pencil through the middle of the circle, spin like a top to see the effect . Review the story of Noah and the significance of the first rainbow. Read children's books such as: Ehlert's *Planting a Rainbow,* Freeman's, *A Rainbow of My Own,* or Friend's *My Head Is Full of Colors.*

References

Ehler, Lois. *Planting a Rainbow.* San Diego: Harcourt, Brace, Jovanovich, 1988.
Freeman, Don. *A Rainbow of My Own.* New York: Viking Press, 1966.
Friend, Catherine. *My Head Is Full of Colors.* New York: Hyperion Books, 1994.

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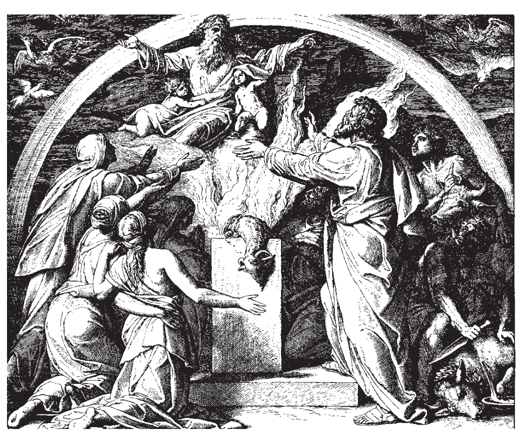


22. Global Warming Indicator—Detecting Carbon Dioxide

Equipment Needed

Bromothymol blue indicator, ammonia, vinegar, baking soda, water, funnel and rubber tubing, graduated cylinder, test tubes, droppers, bottle (about 0.5jl), bicycle pump, balloons, card stock or heavy paper, vehicle (used for collecting exhaust), balloon gauge (see procedure for instructions to make this)

Purpose

To show that different sources produce varying amounts of carbon dioxide

Safety—Special Considerations

Bromothymol blue and ammonia should be handled following conventional lab safety procedures. When preparing the solution, protective gloves and goggles are advisable. Use care when collecting vehicle exhaust.

Grade Level—Time Needed

Grades 4-10; Time: one class period

Background

Carbon dioxide is thought to be depleting the ozone layer which some estimate may contribute about 71% of the greenhouse effect. Reducing the amounts of carbon dioxide in the atmosphere may help reduce the effects of global warming.

Bromothymol blue is an acid/base indicator that changes from yellow (6.0 pH), to green, to blue (7.6 pH). It is used to test the presence and intensity of carbon dioxide. The bromothymol blue solution changes to green and then yellow with increasing intensity of carbonic acid created when the carbon dioxide is in contact with the solution.

Procedure

◆ Advance preparation: make a balloon gauge by cutting a 4" diameter hole in the piece of card stock. Use by putting the balloon inside the hole as it is blown up. This will keep the balloon size constant for each test.

1. Have students rank the following substances by stating which they think will make the most carbon dioxide: gas from your breath, gas from the room, gas from a chemical reaction from vinegar and baking soda, gas from a car's exhaust.
2. Make a control test tube by combining 10 ml of water and 20 drops of bromothymol blue. Label the tube and save this solution for future reference. Describe the color in the data table.
3. Prepare four more test tubes the same way and label them: "Breath," "Room Air," "Chemical Air," and "Vehicle Exhaust."
4. Blow up a balloon with your mouth to 4" in diameter using the balloon gauge. Stretch the balloon over the top of the test tube labeled "Breath" and pour back and forth about 10 times. Describe the color in the data table, and compare the color of the this test tube with the color of the control tube.
5. Add drops of ammonia to the tube until it matches the color of the control tube. Record the number of drops needed in the data table. (The more drops of ammonia used, the greater the intensity of carbon dioxide.)
6. Blow up a balloon with the bicycle pump to 4" in diameter using the balloon gauge. Stretch the balloon over the top of the test tube labeled "Room Air" and pour back and forth about 10 times. Describe the color in the data table, and compare the color of this test tube

with the color of the control tube. Repeat step 5.

7. Measure 50 ml of vinegar and place it in the bottle. Add one teaspoon of baking soda and place it in the bottle. Quickly cover the bottle with a balloon and allow it to inflate in the balloon gauge. Stretch the balloon over the top of the test tube labeled “Chemical Air” and pour it back and forth about 10 times. Describe the color in the data table, and compare the color of this test tube with the color of the control tube. Repeat step 5.
8. Take the funnel, tubing, and a balloon outside. Caution suggests that the teacher collect the exhaust from the vehicle. The teacher will start the vehicle. Hold the funnel, tubing, and balloon on the exhaust pipe to collect a sample. Inflate the balloon to 4" using the balloon gauge. Stretch the balloon over the top of the test tube labeled “Car Exhaust” and pour back and forth at least 10 times. Describe the color in the data table, and compare the color of the this test tube with the color of the control tube. Repeat Step 5.
9. Have students rank the substances as to which made the most carbon dioxide: gas from your breath, gas from the room, gas from a chemical reaction from vinegar and baking soda, gas from a car’s exhaust.

Assignment

Complete the data table. Describe why reducing the amount of carbon dioxide is beneficial to the environment.

Christian Application

The earth does not belong to human inhabitants. God tells us in Psalm 24:1, “The earth is the Lord’s, and everything in it.” We are stewards or managers of the earth. As faithful managers of God’s earth, we will do everything within our power to care for and preserve the earth for future generations. Monitoring and reducing our carbon dioxide output is within our capacity.

Extension

Ask the following questions: *How does this compare with your original prediction? What are the major sources of carbon dioxide being added to the atmosphere? What are some ways you could reduce carbon dioxide from entering the atmosphere?*

Collect gas samples from other sources. Possible sources may include exhaust from a diesel engine or from other types of chemical reactions.

References

The Earthworks Group. *50 Simple Things You Can Do To Save the Earth.* (Distributed free by Aid Association for Lutherans. Appleton, WI.)

Wisconsin. DNR Bureau of Information and Education. *EE News Environmental Education In Wisconsin*, 1993. (P.O. Box 7921, Madison, WI 53707, 608-267-5239)

SG & WS

Data Table
(Lesson 22)

Substance	*Color*	*Drops of Amonia (#)*
Control		
Breath		
Room air		
Chemical Air		
Vehicle exhaust		

23. Wildlife Manager

Equipment Needed

Paper and pencil, category cards, dice (one die for each student)

Purpose

To simulate wildlife management situations
To evaluate hypothetical wildlife management decisions
To identify four factors which can affect the size of wildlife populations

Grade Level—Time Needed

Grades 6-12; Time: one or two class periods

Background

Wildlife managers try to keep healthy wildlife populations, while positive and negative factors influence those populations. These factors include loss of habitat, weather conditions, pollution, development of natural resources, just to name a few. Most people are not aware of the effects these factors have on wildlife.

Procedure

- ◆ Advance preparation: duplicate and cut the category cards
- ◆ Each student is to role play a wildlife manager responsible for a deer population. Each wildlife manager begins the simulation with 100 animals. The manager's goal is to end the simulation with a population capable of reproducing and continuing its existence. If a manager's population drops to less than 10 or increases to more than 200 animals, the manager no longer has a herd to manage and must observe other managers for the duration of the activity.
- ◆ Category cards are separated into three decks with a total of 36 cards: a Situation deck (18 cards), a Reproduction deck (nine cards), and a Wildlife Management deck (nine cards). Shuffle each deck, keeping them separate.
- ◆ This activity can be done either in small groups or with the whole class. The teacher or one of the students in each group draws a sequence of four cards from the decks in the following order: Situation card, Reproduction card, Situation card, Wildlife Management card. Drawing each card is thought of as a different season of the year. After the Wildlife Manager card is drawn, four seasons have passed and a year (round) ends. The full simulation lasts nine years (nine rounds).
- ◆ As each card is drawn, the teacher or one of the wildlife manager reads it aloud to the rest of the managers. Each manager then rolls his or her own die and follows the instructions on the card to calculate his or her herd's new size. Any calculations resulting in fractions should be rounded to the nearest whole number. Each student keeps a record of the population after each year.
- ◆ Close the activity with a class discussion on any number of the following topics. Compare how the use of dice is both reasonable and unreasonable in the realities of wildlife management. Compare apparent benefits and hazards to management decisions. Discuss how populations managed with different strategies may have led to a variety of results. Lead students to realize that wildlife management is far more complicated than this simulation can portray. Discuss ways that habitat could be improved for sustaining populations. Encourage discussion on whether or not human management of wildlife populations is necessary.

Assignment

Name four factors that can affect the size of a wildlife population.

Christian Application

Humans are managers or stewards of the gifts God has given to us. We can easily fall into thinking that we humans own earthly resources as our own possessions. Psalm 50:10-11 says, "For every animal of the field is mine, and the cattle on a thousand hills. I know every bird in the mountains, and the creatures of the field are mine." Our Heavenly Father has empowered us to care for his creation. Genesis 1:28 announces, "Rule over the fish of the sea and the birds of the air and over every living creature that moves on the ground." We have a responsibility to be faithful managers of the resources we have been given. Luke 12:48 reports, "From everyone who has been given much, much will be demanded; and from the one who has been entrusted with much, much more will be asked."

Extension

- ◆ The teacher or the students can modify the Category cards to suit the management of populations of other animals. (e.g. wolf, moose, great blue herons, salmon)
- ◆ The numbers on the Category cards are relatively arbitrary. They should not be interpreted literally. Modify the numbers on the cards to add variety to the simulation.
- ◆ Add an economic perspective to the simulation. Managers who allow hunting will have assets for special projects like habitat development derived from the sale of hunting licenses. Expenses might include salaries of managers, research funding, and forage for animals during severe weather conditions.

References

Charles, Cheryl. *Project Wild*. Western Regional Environmental Education Council. 1986. (P.O. Box 18060, Boulder, CO 80308-8060, 303-444-2390)

SG & WS

Situation Cards

Duplicate the two Situation card pages in the same color to aid in the separation of card decks.

Situation Card
Habitat Destruction

A large wooded area is developed as a subdivision, destroying critical habitat. Decrease your herd by five times your roll.

Situation Card
Weather Influence

Six consecutive days of unusually high temperatures have had a serious negative influence on the survival of your herd. Decrease your herd by the percentage equal to five times your roll.

Situation Card
Habitat Destruction

Wetlands have been partially drained and developed into a golf course, destroying critical habitat. Decrease your herd by five times your roll.

Situation Card
Weather Influence

Several warm and sunny February days have had a dramatic positive influence on the survival of your herd. Increase your herd by the percentage equal to five times your roll.

Situation Card
Predators

Your herd has been attacked by predators. Decrease your herd by the percentage equal to your roll.

Situation Card
Weather Influence

A winter blizzard has had a serious negative influence on the survival of your herd. Decrease your herd by the percentage equal to five times your roll.

Situation Card
Disease

Your herd has been invaded by disease. Decrease your herd by the number you roll.

Situation Card
Weather Influence

Rain finally broke the hot summer drought, having a dramatic positive influence on the survival of your herd. Increase your herd by the percentage equal to five times your roll.

Situation Card
Poachers

Poaching—the illegal killing of animals has reduced herd. Decrease your herd by two times your roll.

Situation Cards

Duplicate the two Situation card pages in the same color to aid in the separation of card decks.

Situation Card

Habitat Loss

A large river was dammed for a hydroelectric plant, flooding essential habitat upstream. Decrease your herd by five times your roll.

Situation Card

Habitat Abuse

The use of pesticides (insect killing chemicals) has increased, harming essential habitat. Decrease your herd by three times your roll.

Situation Card

Habitat Loss

A careless camper left her campfire aglow as she broke camp. The ensuing blaze cleared over 300 acres of prime hardwood forest, destroying habitat. Decrease your herd by five times your roll.

Situation Card

Habitat Abuse

The use of herbicides (plant killing chemicals) has increased, harming essential habitat. Decrease your herd by three times your roll.

Situation Card

Habitat Loss

A local industry had unknowingly released chemical compounds into a stream for several years, destroying essential habitat. Decrease your herd by five times your roll.

Situation Card

Habitat Abuse

A petroleum transport truck overturned on the highway, harming essential habitat. Decrease your herd by three times your roll.

Situation Card

Habitat Loss

A lumbering company clear cut trees from a wooded area, destroying essential habitat. Decrease your herd by five times your roll.

Situation Card

Habitat Abuse

A well meaning garden club hosted a “Back to Nature Day” in the local woods. Hundreds of people carelessly left the area in a shambles, harming essential habitat. Decrease your herd by three times your roll.

Situation Card

Habitat Loss

A portion of a wooded area was developed into a recreation area for humans, destroying essential habitat. Decrease your herd by five times your roll.

Reproduction Cards

Duplicate this page on a unique color to aid in the separation of card decks.

Reproduction Cards

Average Year

This has been an average reproduction year. Increase your herd by following the instructions.
If your current herd's population is

- Over 50 animals, follow this equation (100 + your current herd size) x your roll x 3
- Between 50 and 10 animals, increase your population by three times your roll.
- Under 10, you may not reproduce.

Reproduction Cards

Excellent Year

This has been an excellent reproduction year. Increase your herd by following the instructions.
If your current herd's population is:

- Over 50 animals, follow this equation: (100 + your current herd size) x your roll x 5
- Between 50 and 10 animals, increase your population by five times your roll.
- Under 10, you may not reproduce.

Reproduction Cards

Average Year

This has been an average reproduction year. Increase your herd by following the instructions.
If your current herd's population is

- Over 50 animals, follow this equation (100 + your current herd size) x your roll x 3
- Between 50 and 10 animals, increase your population by three times your roll.
- Under 10, you may not reproduce.

Reproduction Cards

Excellent Year

This has been an excellent reproduction year. Increase your herd by following the instructions.
If your current herd's population is:

- Over 50 animals, follow this equation (100 + your current herd size) x your roll x 5
- Between 50 and 10 animals, increase your population by five times your roll.
- Under 10, you may not reproduce.

Reproduction Cards

Average Year

This has been an average reproduction year. Increase your herd by following the instructions.
If your current herd's population is

- Over 50 animals, follow this equation (100 + your current herd size) x your roll x 3
- Between 50 and 10 animals, increase your population by three times your roll.
- Under 10, you may not reproduce.

Reproduction Cards

Excellent Year

This has been an excellent reproduction year. Increase your herd by following the instructions.
If your current herd's population is

- Over 50 animals, follow this equation (100 + your current herd size) x your roll x 5
- Between 50 and 10 animals, increase your population by five times your roll.
- Under 10, you may not reproduce.

Reproduction Cards

Average Year

This has been an average reproduction year. Increase your herd by following the instructions.
If your current herd's population is

- Over 50 animals, follow this equation (100 + your current herd size) x your roll x 3
- Between 50 and 10 animals, increase your population by three times your roll.
- Under 10, you may not reproduce.

Reproduction Cards

Average Year

This has been an average reproduction year. Increase your herd by following the instructions.
If your current herd's population is

- Over 50 animals, follow this equation (100 + your current herd size) x your roll x 3
- Between 50 and 10 animals, increase your population by three times your roll.
- Under 10, you may not reproduce.

Reproduction Cards

Average Year

This has been an average reproduction year. Increase your herd by following the instructions.
If your current herd's population is

- Over 50 animals, follow this equation (100 + your current herd size) x your roll x 3
- Between 50 and 10 animals, increase your population by three times your roll.
- Under 10, you may not reproduce.

Wildlife Management Cards

Duplicate this page on a unique color to aid in the separation of card decks.

Wildlife Management Card
Research

Research on expanding human recreation areas has been accomplished. Decrease your herd by two times your roll.

Wildlife Management Card
Habitat Restoration

Habitat restoration has occurred, restoring essential habitat. Increase your herd by the percentage equal to five times your roll

Wildlife Management Card
Law Enforcement

Law enforcement activities have protected the herd from illegal hunting. Increase your herd by the percentage equal to two times your roll or by two times your roll. (Manager's choice)

Wildlife Management Card
Habitat Conversion

Developers abandon an area because of pressure from environmentalists. Increase your herd by the percentage equal to three times your roll.

Wildlife Management Card
Education

National Wildlife Service education activities have led to increased understanding of wildlife and habitat. Increase your herd by the percentage equal to two times your roll, or by two times your roll. (Manager's choice)

Wildlife Management Card
Habitat Conversion

Much rain has eroded polluted soil into habitat areas. Decrease your herd by the percentage equal to three times your roll.

Wildlife Management Card
Habitat Purchase

The state legislature has approved the purchase of land for the purpose of a wildlife refuge. Increase your herd by the percentage equal to three times your roll.

Wildlife Management Card
Habitat Recovery

Volunteers have planted tree saplings to reforest an area, reclaiming essential habitat. Increase your herd by the percentage equal to three times your roll.

Wildlife Management Card
Hunting

A request for hunting has been made. Do you wish to allow hunting in your area? If yes, decrease your herd by the percentage equal to five times your roll. If no, decrease your herd by the number you roll. (Manager's choice)

24. Genetics—Understanding Genotype-Phenotype

Equipment Needed

Dark-colored construction paper, clear plastic sheets

Purpose

To understand genotype-phenotype

Grade Level—Time Needed

Grades 7-10; Time: 20 minutes

Background

Gregor Mendel's law of dominant and recessive traits reflects an interaction between two genes. The phenotype is a description of the trait as it appears in the organism. A red or white color of a flower blossom is an example. The genotype is a description of the traits carried by the genes. A plant may carry two genes for white, one gene for each white and red, or two genes for red. In the case where the two genes are different, the dominant gene will be expressed in the phenotype.

Procedure

Cut two strips of dark-colored construction paper and two strips of clear plastic for each team of students. (approximately 5 cm by 3 cm) The dark color represents a dominant gene and the clear plastic (no color) represents a recessive gene. The phenotype is the trait as it appears in the offspring. The phenotype of an organism is described as "dark" or "clear." The genotype is the gene combination. The genotype of an organism is stated as having the following possible combination of genes: DD (two dominant genes for color), Dd (one dominant and one recessive gene for color), or dd (two recessive genes for color). The following questions are on a separate black-line master for the students.

1. Place one dark-colored strip on top of the other dark-colored strip. Shade in the blank rectangle below to show this combination of genes. Then fill in the blanks in the sentence.
   The phenotype is *(dark)*; the genotype is *(DD)*.
2. Place one dark-colored strip on top of one clear plastic strip. Shade in the rectangle to show the result. Then fill in the blanks in the sentence.
   The phenotype is *(dark)*; the genotype is *(Dd)*.
3. Place one clear plastic strip over one dark-colored strip. Shade in the rectangle to show the result. Then fill in the blanks in the sentence.
   The phenotype is *(dark)*; the genotype is *Dd*.
4. Place one clear plastic strip over the other clear plastic strip. Shade in the rectangle to show the result. Then fill in the blanks in the sentence.
   The phenotype is *(clear)*; the genotype is *(dd)*.

When teams have completed the four items above, discuss in a whole class grouping how the inheritance of dominant and recessive genes helps produce variation in a population.

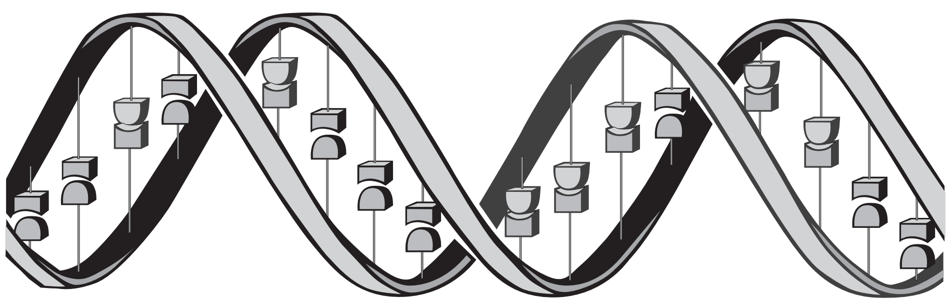
Christian Application

With what great variation God has blessed all species. Creatures can carry traits in their genes that are hidden in certain combinations and expressed in other combinations. We should be satisfied with the gifts God has given us.

Extension

Phenotypes are what you see. Sometimes the genotype is not fully expressed. For example, a person may not reach full height if food is not available. On the other hand, people sometimes try to change their phenotype. Students could make a list of ways in which people try to change the way they look. Read 2 Corinthians 12:7. Why did not God take away St. Paul's "thorn"?

ERT



Activity Sheet for Lesson 24

1. Place one dark-colored strip on top of the other dark-colored strip. Shade in the blank rectangle below to show this combination of genes. Then fill in the blanks in the sentence.

   The phenotype is __________; the genotype is _____________.

2. Place one dark-colored strip on top of one clear plastic strip. Shade in the rectangle to show the result. Then fill in the blanks in the sentence.

   The phenotype is __________; the genotype is ___________.

3. Place one clear plastic strip over one dark-colored strip. Shade in the rectangle to show the result. Then fill in the blanks in the sentence.

   The phenotype is ___________; the genotype is __________.

4. Place one clear plastic strip over the other clear plastic strip. Shade in the rectangle to show the result. Then fill in the blanks in the sentence.

   The phenotype is __________; the genotype is ___________.

25. Genetics—Investigating the Law of Segregation

Equipment Needed

A penny, a nickel

Purpose

To see how the combining of the parents' genes in the offspring follows a predictable pattern

Grade Level—Time Needed

Grades 5-9; Time: one class period

Background

Gregor Mendel was the father of genetics. He developed a number of laws which expressed the interaction between genes. Without knowing it, Mendel was describing the result of the cellular division meiosis. During meiosis, the genetic material duplicates itself and subsequently divides two times. Because the first of these divisions separates the genes carrying the same trait, the law is know as the law of segregation. The second division reduces the genetic material from the diploid state to the haploid state found in sperm and egg. In the simulation, the separation of traits is represented by the heads and tails of the coin. The tossing and showing of only one of the traits shows the haploid state. The possible combinations of the heads and tails or haploid sperm and egg follows a pattern of 1:2:1.

Procedure

Use a penny to represent a male parent and a nickel to represent a female parent. Let the heads represent a dominate gene and the tails represent a recessive gene. Toss the penny and nickel in pairs fifty times. One penny toss and one nickel toss represent one combination for one offspring. Record your penny—nickel toss in one of the four boxes in the table below. In the top left box place a tally mark if the two coins come up heads; in the top right if the penny comes up tails and the nickel heads; in the bottom left box if the penny comes up heads and the nickel tails; and in the bottom right box if the two coins come up tails. Repeat tossing penny and nickel pair for fifty times. Each time record the results in the appropriate box. Remember the sum of the four boxes should be a total of 50 tally marks.

		Penny Male parent	
		Heads (Dominant)	**Tails** (Recessive)
Nickel Female parent	**Heads** (Dominant)		
	Tails (Recessive)		

Questions:

- *If each penny-nickel toss represents one offspring receiving one gene from each parent, how many offspring have two genes with the dominant trait?*
- *How many offspring are hybrid receiving one gene for dominance and one gene for recessive?*
- *How many offspring have two genes for the recessive trait?*
- *Express your results as a Mendelian ratio* (the number of offspring with two genes for dominance: the number of hybrid: the number with two genes for recessive)
- *Do the results come close to the Mendelian ratio of 1:2:1?*
- *If your results were not exactly in a 1:2:1 ratio, explain why this may have happened.*

Family Involvement

At home have each family member repeat the 50 tosses and compare their results to yours.

Christian Application

God has provided for a wonderful variety among a given species through the sorting of genes through meiosis and the recombining of genes in sexual reproduction. Even though these offspring pattern of traits is predictable, our all-wise and all-powerful God can choose to combine genes outside the predictable pattern

Extension

In the next class period combine the tosses of all the class members and compare to the Mendelian ratio. *Do the combined results come closer to the predicted than the results of the individuals? Why?*

References

Adapted from Perkins, Otho. *Life Sciences Work-a-Text.* Columbus, Ohio: Globe-Fearon, 1978.

ERT

Penny Male parent

		Heads (Dominant)	**Tails** (Recessive)
ckel nale ·ent	**Heads** (Dominant)		
	Tails (Recessive)		

Questions:

- If each penny-nickel toss represents one offspring receiving one gene from each parent, how many offspring have two genes with the dominant trait?
- How many offspring are hybrid receiving one gene for dominance and one gene for recessive?
- How many offspring have two genes for the recessive trait?
- Express your results as a Mendelian ratio: the number of offspring with two genes for dominance: the number of hybrid: the number with two genes for recessive)
- Do the results come close to the Mendelian ratio of 1:2:1?
- If your results were not exactly in a 1:2:1 ratio, explain why this may have happened.

26. Genetics—Mitosis, Meiosis, and Mochro Creatures

Equipment Needed

Mochro creature chromosomes, scissors

Purpose

To explore the differences between mitosis and meiosis
To understand the changes in the number of chromosomes in mitosis and meiosis

Grade Level—Time Needed

Grades 7-10; Time: one class period

Background

This activity is intended to be a follow up exercise after the presentation of mitosis and meiosis.

Procedure

Models of the chromosomes of the very fictitious Mochro creature are included with this activity. Chromosomes carry genes.The dark bands on these models are genes. Genes are important to all creatures because they pass on the inherited traits. All cells in the Mochro's body contain the same number and type of chromosomes. Follow these directions: (The worksheet on page 3.70 contains identical questions.)

- ❑ Step 1: Cut out each chromosome model.
- ❑ Step 2: Fold each paper model in half along dotted lines.
- ❑ Step 3: Match in pairs as many chromosome models as possible. A chromosome pair must match in length as well as in number and location of the genes.
- ❑ Step 4: Answer the questions:
  - ◆ *How many chromosomes can be found in each of the Mochro's cells?* (14)
  - ◆ *How many matched pairs of chromosomes are there in each cell?* (6)
  - ◆ *How many unmatched chromosomes are there in each cell?* (2)
  - ◆ *Do the genes on each matched pair of chromosomes also match?* (yes)
- ❑ Step 5: Now cut each chromosome model in half along the dotted line. Make two piles of chromosome halves by placing one half of each chromosome in one pile and the other half in the second pile.
- ❑ Step 6: Answer the questions:
  - ◆ *How many chromosomes are in each of the two piles?* (14)
  - ◆ *Are the chromosomes in each pile similar or different?* (similar)
  - ◆ *Which kind of cell division is represented by step 5?* (mitosis)

A process of cell division called mitosis occurs in most living creatures in their body cells. During mitosis the chromosomes duplicate, then separate, and the parent cell divides to produce two daughter cells. The cutting of each chromosome model and separating them into two piles represents what happens in a living cell. The two piles of chromosome models represent two new body cells.

- ❑ Step 7: Place all identical chromosome models together in separate groups. You should have 6 groups of four identical models, and a seventh group of the four unmatched models.
- ❑ Step 8: Take each group of matched chromosomes and separate into four piles. Do the same with the unmatched group. Each of the four piles of chromosome models now represents a sex cell.
- ❑ Step 9:Answer the questions:
  - ◆ *How many chromosomes are found in Mochro sex cells?* (7)

- *Do any chromosomes match one another within a sex cell?* (no)
- *Which kind of cell division is represented by steps 7 and 8?* (meiosis)

A process of cell division called meiosis occurs in most living creatures in their sex cells. During meiosis the chromosomes first duplicate, and the cell divides the first time. Then the chromosomes separate, and the cell divides a second time. One parent cell divides to produce four daughter cells.

- Male Mochros have six matched pairs of chromosomes and two unmatched chromosomes. Female Mochros have seven matched pairs of chromosomes. *Were the chromosomes in our creature taken from a male or a female?* (male)
- *Are all cells produced by mitosis exactly alike, chromosome for chromosome?* (yes) *gene for gene?* (yes) *Explain.* (duplication)
- *How does the number of chromosomes in sex cells compare to the number of chromosomes in cells formed during mitosis?* (half)
- *Tell two ways in which sex cells differ from body cells.* (not paired, half the number)

Assignment

Draw a diagram of the process of mitosis and a second diagram of the process of meiosis. Pretend that your creature has three chromosomes, a rod, a triangle, and a square. Use circles to represent the cells. Label each diagram and the parts of each diagram.

Christian Application

God has provided for continuity and diversity among his creatures. Mitosis is our explanation of how God gives continuity within organisms of the same species. By mitosis, the major morphological structures of the same species remain the same. Meiosis is our explanation of how God gives diversity within organisms of the same species. By meiosis, the morphological traits are shown in a variety of diverse ways. Praise God for his infinite wisdom.

Extension

Human body cells have 46 chromosomes in 23 pairs. Human sex cells have 23 chromosomes.

References

Heimler, Charles H. *Focus on Life Science.* Columbus, Ohio: Merrill, 1984.

ERT

Worksheet, Lesson 26

Models of the chromosomes of the very fictitious Mochro creature are included with this activity. Chromosomes carry genes.The dark bands on these models represent the genes. Genes are important to all creatures because they pass on the inherited traits. All the cells in Mochro's body contain the same number and type of chromosomes. Please follow the directions.

- ❑ Step 1: Cut out each chromosome model.
- ❑ Step 2: Fold each paper model in half along dotted lines.
- ❑ Step 3: Match in pairs as many chromosome models as possible. A chromosome pair must match in length as well as in number and location of the genes.
- ❑ Step 4: Answer the questions:
  - ◆ How many chromosomes can be found in each of the Mochro's cells?

    ____
  - ◆ How many matched pairs of chromosomes are in the cell?

    ____
  - ◆ How many unmatched chromosomes are in the cell?

    ____
  - ◆ Do the genes on each matched pair of chromosomes also match?

    ____
- ❑ Step 5: Now cut each chromosome model in half along the dotted line. Make two piles of chromosome halves by placing one half of each chromosome in one pile and the other half in the second pile.
- ❑ Step 6: Answer the questions:
  - ◆ How many chromosomes are in each of the two piles?

    ____
  - ◆ Are the chromosomes in each pile similar or different?

    ____
  - ◆ Which kind of cell division is represented by step 5?

    ____

A process of cell division called mitosis occurs in body cells. During mitosis the chromosomes duplicate, then separate, and the parent cell divides to produce two daughter cells. The cutting of each chromosome model and separating them into two piles represents what happens in a living cell. The two piles of chromosome models represent two new body cells.

- ❑ Step 7: Place all identical chromosome models together in separate groups. You should have six groups of four identical models, and a seventh group of the four unmatched models.
- ❑ Step 8: Take each group of matched chromosomes and separate into four piles. Do the same with the unmatched group. Each of the four piles of chromosome models now represents a sex cell.
- ❑ Step 9: Answer the questions:
  - ◆ How many chromosomes are found in Mochro sex cells?

    ____
  - ◆ Do any chromosomes match one another within a sex cell?

    ____
  - ◆ Which kind of cell division is represented by steps 7 and 8?

    ____

A process of cell division called meiosis occurs in most living creatures in their sex cells. During meiosis the chromosomes first duplicate, and the cell divides the first time. Then the chromosomes separate, and the cell divides a second time. One parent cell divides to produce four daughter cells.

- ◆ Male Mochros have six matched pairs of chromosomes and two unmatched chromosomes. Female Mochros have seven matched pairs of chromosomes. Were the chromosomes in our creature taken from a male or a female?

  ____
- ◆ Are all cells produced by mitosis exactly alike, chromosome for chromosome? gene for gene?

  ____

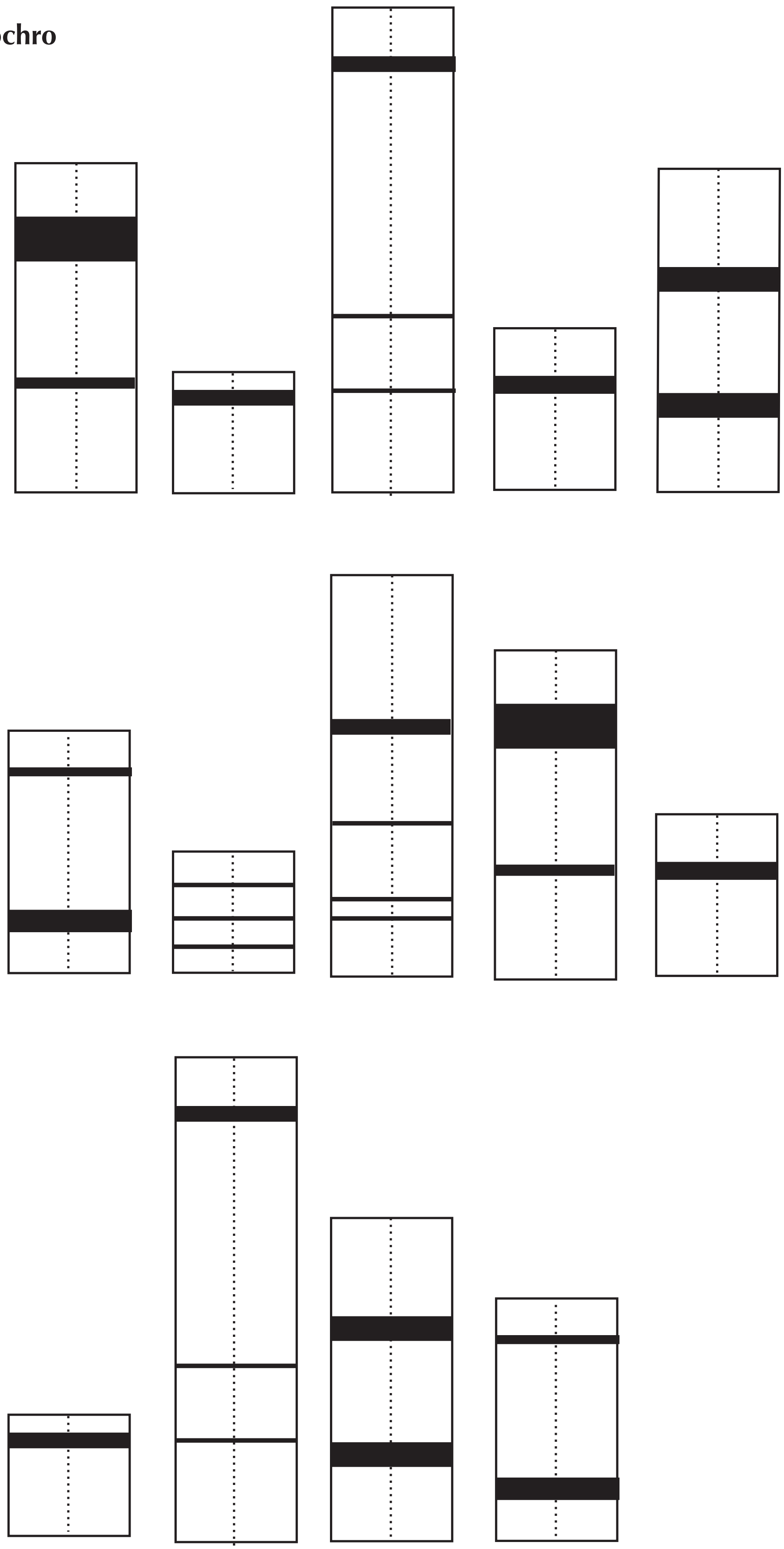
  Explain why.

  ____
- ◆ How does the number of chromosomes in sex cells compare to the number of chromosomes in cells formed during mitosis?

  ____
- ◆ Tell two ways in which sex cells differ from body cells.

  ____

The Mochro



27. Genetics—Multiple Gene Inheritance

Equipment Needed

Five different colored pencils, one sheet of white paper per person, metric ruler

Purpose

To answer the question: Is hand size controlled by multiple genes?

Grade Level—Time Needed

Grades 7-10; Time: one class period

Background

Traits controlled by single genes are usually distinct from each other. Attached and lobed ear lobes and ability to roll and not roll the tongue are examples. Traits which show a great diversity are controlled by more than one gene. The variety between hand size, width, and length does not show the distinct dichotomy of one gene, but rather the action of many genes. Thus hand size is controlled by multiple genes. By measuring more students the teachers can demonstrate a greater variety.

Procedure

- Place your left hand palm down on a sheet of paper.
- Trace around your left hand carefully with a colored pencil. Make a mark on the paper to show the bottom of your hand (where the top of your wrist watch band would be).
- Put your initials in the lower right hand corner of the paper using the same colored pencil.
- Draw a straight line segment across the widest part of the tracing of your hand. Measure the line segment and record the measurement on a chart like the one below.
- Draw a straight line segment from the tip of your middle finger in the drawing to the point marking the bottom of your hand. Measure the line segment and record the measurement.
- Ask a classmate to place his/her left hand palm down on top of the drawing of your left hand. Using a different colored pencil, trace his/her hand. Be sure to place your classmate's initials on the bottom of the page next to yours using the same colored pencil that you used to trace your classmate's hand.
- Measure and record your classmate's hand width and hand length.
- Find three more classmates and do the same with each. You now should have data for a total of five classmates including yourself.
- Determine hand size for yourself and the four classmates by multiplying the hand width by the hand length. Record this data in the chart.

Person	Hand width	Hand length	Hand size

Questions:

1. Which person had the smallest
   a. hand width? ______________________
   b. hand length? ______________________
   c. hand size? ______________________
2. Which person had the largest
   a. hand width? ______________________
   b. hand length? ______________________
   c. hand size? ______________________
3. Calculate the average
   a. hand width? __________
   b. hand length? __________
   c. hand size? __________
4. What is the median
   a. hand width? __________
   b. hand length? __________
   c. hand size? __________

(Median is the middle value below and above which there is an equal number of values.)

5. Does the data indicate that hand size is controlled by one pair or multiple pairs of genes? Please explain.

   ____

Christian Application

God in his infinite wisdom has given the human race more variety by creating many human traits which are controlled by multiple genes. How might smaller hands be a blessing from God in ones life? How might larger hands be especially helpful in one's life? Praise and thank God that even though we humans have been created alike with two hands, we also have been created with a great variety of hand sizes.

Extension

Explore with the class what other human traits they think might be controlled by multiple genes.

References

Heimler, Charles H. *Focus on Life Science.* Columbus, Ohio: Merrill, 1984.

ERT

Worksheet, Lesson 27

- Place your left hand palm down on a sheet of paper.
- Trace around your left hand carefully with a colored pencil. Make a mark on the paper to show the bottom of your hand (where the top of your wrist watch band would be).
- Put your initials in the lower right hand corner of the paper using the same colored pencil.
- Draw a straight line segment across the widest part of the tracing of your hand. Measure the line segment and record the measurement on a chart like the one below.
- Draw a straight line segment from the tip of your middle finger in the drawing to the point marking the bottom of your hand. Measure the line segment and record the measurement.
- Ask a classmate to place his/her left hand palm down on top of the drawing of your left hand. Using a different colored pencil, trace his/her hand. Be sure to place your classmate's initials on the bottom of the page next to yours using the same colored pencil that you used to trace your classmate's hand.
- Measure and record your classmate's hand width and hand length.
- Find three more classmates and do the same with each. You now should have data for a total of five classmates including yourself.
- Determine hand size for yourself and the four classmates by multiplying the hand width by the hand length. Record this data in the chart.

Person	Hand width	Hand length	Hand size

Questions:

1. Which person had the smallest
   a. hand width? ______
   b. hand length? ______
   c. hand size? ______
2. Which person had the largest
   a. hand width? ______
   b. hand length? ______
   c. hand size? ______
3. Calculate the average
   a. hand width? ______
   b. hand length? ______
   c. hand size? ______
4. What is the median
   a. hand width? ______
   b. hand length? ______
   c. hand size? ______

(Median is the middle value below and above which there is an equal number of values.)

5. Does the data indicate that hand size is controlled by one pair or multiple pairs of genes? Please explain.

______

28. Genetics—Probability and the Combining of Genes

Equipment Needed

Two paper bags, 100 red beans, 100 white beans per lab group

Purpose

To see how probability affects the combination of genes

Grade Level—Time Needed

Grades 6-9; Time: one class period

Background

The reproduction of most plants, most animals, and humans is sexual. Sexual reproduction involves the production of gametes, sperm and egg. Sperm and eggs each carry one set of the genes. In sperm and egg production, cell division reduces the normal diploid (2N , two sets of genes) to haploid (1N, one set of genes). In hybrids the two sets of genes are not the same. Each parent gives in the making of sperm and egg one of the two possible sets of genes. Two parents giving two possible sets of genetic information makes for four possible combinations.

Procedure

- ◆ Place 50 red beans and 50 white beans in one paper bag. Do the same in the other paper bag.
- ◆ Hold the tops of the bags closed and shake each bag several times.
- ◆ Without looking inside the bags, remove one bean from each bag. Record the colors of the bean by making a tally mark in one of the four columns in the chart below. Group your tallies by fives.
- ◆ Put each bean back in its own bag.
- ◆ Repeat steps 2,3,4 ninety-nine more times.
- ◆ Count up the tallies in each of the four columns.

Red-Red	Red-white	white-Red	white-white

Questions:

Pretend that the beans are genes of new plants. Red is dominant and white is recessive.

1. *How many new plants would have pure (Red- Red) dominant genes?*
2. *How many would have pure (white-white) recessive genes?*
3. *How many would be (Red-white, white-Red) hybrids?*
4. *How many combinations are possible using two kinds of beans?* (4)
5. *Why is it necessary to select so many pairs?* (Large samples increases validity)
6. *What is the probability of getting a Red-Red pair?* (25% or 1/4)
7. *What is the probability of getting a Red-white or white-Red pair?* (50% or 1/2)
8. *What is the probability of getting a white-white pair?* (25% or 1/4)

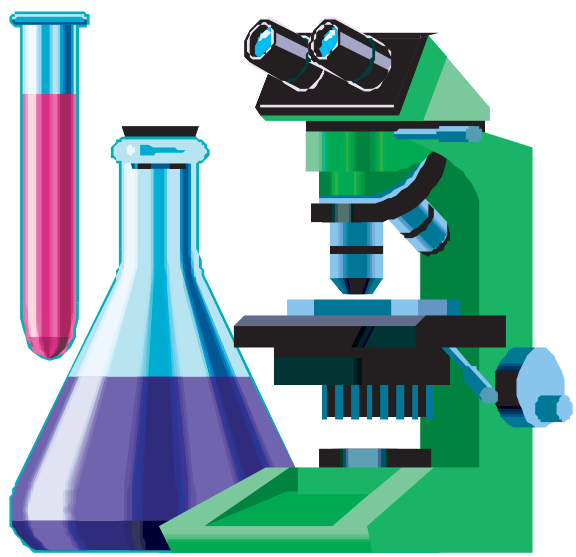
Christian Application

God has given us a seemingly endless variety in human beings and other living creatures. To us this variety seems to happen by chance in a predictable pattern. But God is in control of all things, even the combining of the more than 250,000 human genes. Surely, our Triune God who knows the number of hairs on each of our heads also knows and decides just how our parents' genes will combine.

References

Heimler, Charles H. *Focus on Life Science*. Columbus, Ohio: Merrill, 1984.

ERT



Worksheet Lesson 28

- Place 50 red beans and 50 white beans in one paper bag. Do the same in the other paper bag.
- Hold the tops of the bags closed and shake each bag several times.
- Without looking inside the bags, remove one bean from each bag. Record the colors of the bean by making a tally mark in one of the four columns in the chart below. Group your tallies by fives.
- Put each bean back in its own bag.
- Repeat steps 2,3,4 ninety-nine more times.
- Count up the tallies in each of the four columns.

Red-Red	Red-white	white-Red	white-white

Questions:

Pretend that the beans are genes of new plants. Red is dominant and white is recessive.

1. How many new plants would have pure (Red- Red) dominant genes? ________
2. How many would have pure (white-white) recessive genes? ________
3. How many would be (Red-white, white-Red) hybrids? ________
4. How many combinations are possible using two kinds of beans? ________
5. Why is it necessary to select so many pairs?

____

____

6. What is the probability of getting a Red-Red pair? ________
7. What is the probability of getting a Red-white or white-Red pair? ________
8. What is the probability of getting a white-white pair? ________

29. Genetics—Using Punnett Squares

Equipment Needed

A copy of the five problems on this sheet for each student (see worksheet), an overhead master of the five problems on this sheet for the teacher

Purpose

To introduce students to the use of Punnett squares to show possible combinations of traits

Grade Level—Time Needed

Grades 7-8; Time: 20 minutes

Procedure

The teacher should guide the students through the whole activity. Elicit from the students the letters for the gametes, the positioning above columns and beside rows, the crosses, and the answers. Examine papers for proper labeling, crossing, etc. Students may work as individuals or groups, but do not use this sheet as an assignment unless you have thoroughly worked other Punnett square samples together.

1. *What color will the offspring be if a pure black guinea pig is crossed with a pure white?* black
   Black is dominant in guinea pigs. Use B for black and b for white.
2. *If two hybrid guinea pigs are crossed, what color will the offspring be?*
   some black 3-75%
   some white 1-25%

pure black (columns); pure white (rows)

	B	B
b	Bb	Bb
b	Bb	Bb

3. *If a red four o'clock flower is crossed with a white one, the resulting flowers are pink (blending or incomplete dominance). If two pink four o'clocks are crossed, what percent of the offspring will be red?* 25%
   pink? 50%
   white? 25%

hybrid (columns); hybrid (rows)

	B	b
B	BB	Bb
b	Bb	bb

4. *If a pink four o'clock is crossed with a white one, what percent of their offspring will be red?* 0%
   pink? 50%
   white? 50%

pink		R	r
	R	RR	Rr
	r	Rr	rr

Assignment

5. According to Mendel, round pea seeds are dominant over wrinkled pea seeds. *What offspring would be produced by a cross between a hybrid round seed plant and a wrinkled seed plant?*
   50% hybrid round seed
   50% wrinkled seed

white		R	r (pink)
	r	Rr	rr
	r	Rr	rr

Christian Application

God states we are fearfully and wonderfully made. We get a glimpse of the orderliness in God's creation through the interaction of genes. This helps us understand the nature God has created. In eternity we will see clearly all the ways our God demonstrated orderliness and creativity in his creation.

wrinkled		W	w (hybrid)
	w	Ww	ww
	w	Ww	ww

Extension

Many other crosses can now be tried. Cross four genes for two traits in a 4 x 4 matrix. Challenge students to research and set up their own Punnett squares.

eferences

Heimler, Charles H. *Focus on Life Science.* Columbus, Ohio: Merrill, 1984.

ERT

Worksheet Lesson 29

1. What color will the offspring be if a pure black guinea pig is crossed with a pure white?

Black is dominant in guinea pigs. Use B for black and b for white.

2. If two hybrid guinea pigs are crossed, what color will the offspring be?

Worksheet Lesson 29

3. If a red four o’clock flower is crossed with a white one, the resulting flowers are pink (blending or incomplete dominance). If two pink four o’clocks are crossed, what percent of the offspring will be

red? ________________

pink? ________________

white? ________________

4. If a pink four o’clock is crossed with a white one, what percent of their offspring will be

red? ________________

pink? ________________

white? ________________

5. According to Mendel, round pea seeds are dominant over wrinkled pea seeds. What offspring would be produced by a cross between a hybrid round seed plant and a wrinkled seed plant?

____

30. Plants Give Off Water

Equipment Needed

Geranium, cardboard, petroleum jelly, four glass jars

Purpose

To identify a byproduct of respiration
To see the process of water vapor loss through leaves called transpiration
To observe that one of the products is water

Safety—Special Considerations

If you use glass jars, encourage the children to be cautious. A fresh cut or break of the geranium leaves is best. Prepare them just before you use them.

Grade Level—Time Needed

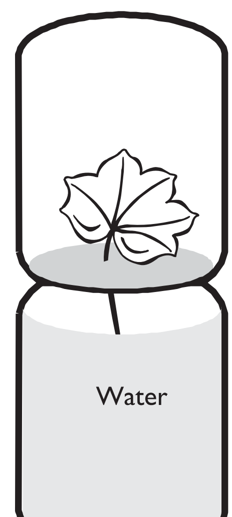
Grades 3-8; Time: one class period with observation a few hours following

Background

Water is a by-product of respiration in plants. During respiration, the sugar and starch from photosynthesis are broken down and combined with oxygen to water. Water is also taken up through the roots. Evaporation of water from the tiny openings of the leaves, stomata, is called transpiration. More than 90% of the water passing through the leaf evaporates. Plants will continue this process even in a dry spell. Without the replenishment of lost water, the plant will wilt.

Procedure

Carefully break off one geranium leaf. In a piece of cardboard, large enough to cover one of the jar openings, carefully punch with the point of a pencil a hole large enough to insert the petiole of the leaf. Smear petroleum jelly in the hole around the petiole so that no air can pass from one side of the cardboard to the other through the hole. Fill one jar with water and place the leaf/cardboard so that the petiole is in the water. Put another jar upside down on the cardboard, over the leaf, so that you have a closed system. Put the system in a sunny window. Check the set-up every hour. Make another two jar set-up, but leave the leaf out. Put this set-up in the same window and check it, too.



Family Involvement

Try this by covering the soil and pot of a house plant with aluminum foil and then placing it under a large jar. Talk about whether house plants can increase the humidity in a home (yes).

Christian Application

God uses plants as part of the incredible plan called the water cycle. Read Job 28:25-28.

Extension

Use colored or dirty water and observe the water color in the top jar. Speculate on the reason and application of the change.

CA

31. Plants Store Product of Photosynthesis as Starch

Equipment Needed

Geranium plant, pins, black paper, iodine, alcohol (80% ethyl), hot plate, two jars sized so that one will fit into the other with room to spare, pie tin, tweezers

Purpose

To identify a form in which plants store energy for future use
To understand another step in the photosynthesis process

Safety—Special Considerations

This activity requires the heating of alcohol. Alcohol is a very flammable liquid and should be handled only by the teacher. Extreme caution should be used when heating the alcohol in the water bath on the hot plate. The water bath should prevent a fire but keep a cover handy to put over the jar if it begins to burn. Alcohol burns with a blue flame. Do not panic and throw water on it. Cover it. Iodine is poisonous and will stain whatever it touches. Students should wash their hands after using the iodine and never place hands or fingers in mouth during the experiment.

Grade Level—Time Needed

Grades 5 and up; Time: one class period

Background

In this procedure, the green chlorophyll of the geranium leaf will be extracted. This is done by boiling the leaf in alcohol. Once the chlorophyll is extracted, the leaf will appear bleached or white. By placing iodine on the white leaf, the presence of starch will be tested. Iodine turns starch blue-black. Starch is a storage form of the sugar produced by photosynthesis. The area of the leaf that was covered for five days was unable to do photosynthesis. Without photosynthesis no sugar is produced and subsequently no starch is stored. The iodine test on the covered part of the leaf will be less dark than the area not covered.

Procedure

Approximately 5 days before the final procedure, fasten with pins a small square or other shape of black paper to both the upper and lower surfaces of a leaf of a geranium plant. Leave the plant in the sun with the paper on the leaves. When ready, remove the leaf from the plant. Unfasten the paper squares and place the leaf in the smaller jar with alcohol. Place the smaller jar into the larger jar partially filled with water. (Be careful that the water does not overflow into the smaller jar or onto the hot plate.) Place the jars onto the hot plate and heat the alcohol to boiling. Students should note the color change taking place in the alcohol. After the leaf has turned almost white, remove the leaf with a tweezer. Wash the leaf thoroughly with tap water to remove the alcohol. Set the leaf in the pie tin and cover with iodine. Students should note the difference in color on the leaf covered by the black shapes.

Christian Application

The Creator has made plants to be producers of energy and provided a way for that energy to be stored for use by plants or animals or people. We see the same basic system used by most plants in God's orderly creation which he made with just his word.

CA

32. Plants Give Off Oxygen (1)

Equipment Needed

Test tube, glass, water, elodea plant

Purpose

To observe that plants produce a gas (oxygen) as a by-product of photosynthesis
To appreciate the importance of oxygen as a by-product in God's created world

Safety—Special Considerations

Caution should be used when handling glass. Elodea *(Anacharis canadensis)* is commonly called elodea, anacharis or waterweed. It is a flowering plant with branching leafy stems which is sold in aquarium stores.

Grade Level—Time Needed

Grades K-8; Time: one class period

Background

During the process of photosynthesis, plants give off oxygen as a by-product. The gas collected in the test tube is oxygen from photosynthesis.

Procedure

Fill the glass about three-fourths full of water. Carefully break a piece of Elodea off the tip about one inch long. Place the piece top first into the test tube. After filling the test tube with water, place the test tube into the jar of water by putting your thumb over the top and turning it over. Release your thumb under the water in the jar to insure that no air is in the test tube at the beginning of the exercise. Leave the jar and tube in a sunny spot for a day and check for a collection of gas in the test tube. After a day, observe the bubbles at the top of the test tube. With a small magnifying glass, observe the small air bubbles at the tips of the leaves.

Christian Application

To preserve a balance and a cycle God created plants to use CO_2 and produce O_2 Animals and people use O_2 and produce CO_2. The two rely on each other. The cycle is how God preserves us.

Extension

How many plants does it take to produce the oxygen we breathe everyday?

CA

33. Plants Give Off Oxygen (2)

Equipment Needed

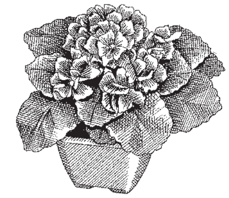
Teaspoon, two funnels, two glass jars able to hold inverted funnel completely under water, ruler, sodium bicarbonate (baking soda), two test tubes, water (leave standing out for 24 hours to remove chlorine), elodea plants

Purpose

To observe that plants require light to do photosynthesis
To appreciate the importance of oxygen as a by-product in God created world

Safety—Special Considerations

Special care should be exercised whenever glass is used.



Grade Level—Time Needed

Grades 3-8; Time: one class period with some follow up

Background

The sodium bicarbonate in water produces extra CO_2 which is used by the plant during photosynthesis. The gas in the test tube is oxygen from the photosynthesis but that can not be deduced from just this experiment. The dark jar plant is not engaging in photosynthesis, hence, the lack of gas in the test tube.

Procedure

Fill each jar with water and add one teaspoon of sodium bicarbonate. Remove about 2cm from the bottom of the elodea plants. Place the elodea plant in the water in each jar and cover it with a funnel. Fill a test tube completely with water. Hold your thumb over the mouth of the test tube and place it over the narrows of the funnel. The test tube must not have any air in it after being placed over the funnel. If some is present, redo the procedure until there is no air in the test tube. Place a test tube over each funnel. Place the jars in a location that receives bright light. (To increase the effectiveness of the exercise, this jar may be placed under a bright light for 24 hours.) Place the other jar in a dark location where no light is present. The next day the jars can be observed and the amount of oxygen in the test tubes measured with a ruler. If many projects were done at the same time, then a class average of gas collected may be obtained.

Christian Application

God created plants to use CO_2 and produce O_2, Animals and people use O_2 and produce CO_2. The two rely on each other to continue. This cycle is one way in which God preserves us.

Extension

Prolonged space flights with humans would use a great deal of oxygen for breathing. How might the cycle be preserved in a small contained area? Design your system or invention to solve this dilemma.

CA

34. Plants Give Off Oxygen (3)

Equipment Needed

Elodea; water; two glass jars; two test tubes; two pieces of tag board, each able to fit over one of the glass jars, and each made with a hole about a quarter inch in diameter; jar; matches; splint (Split popsicle sticks work fine.)

Purpose

To show how scientists can test for oxygen
To appreciate the importance of oxygen as a by-product in God's created world

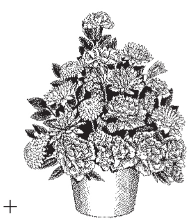
Safety—Special Considerations

Special care should be exercised whenever glass is used. When working with a flame, be sure to wear goggles and to tie back any long, loose hair that hangs in the way. The teacher may wish to do the flame test instead of allowing the students to do it. If the students conduct the test, they should be cautioned and closely supervised during this portion of the exercise. The splint will reignite in the presence of the extra oxygen.

Grade Level—Time Needed

Grades 5 and up; Time: two half hour class periods

Background



Plants need light to do photosynthesis. The plants in the dark will not photosynthesize due to the lack of light. The oxygen is a by-product of the photosynthesis. Photosynthesis can be stated simplistically : carbon dioxide + water + sunlight = sugar + oxygen.

Procedure

Place some of the elodea into each jar. Fill the jars completely full with water. Fill each test tube completely with water. Place the tag board over the test tube, turn it upside down and place it on top of the jars filled with water. Gently slide the test tube over the hole. Be sure that there is no air trapped in the test tube at this time. If there is any air, the process must be redone until properly completed. Follow this same procedure for the other jar. Place one of the jars in a spot that will receive full sunlight. Place the other jar into a dark place like a closet. (To increase the effects of the light jar, the jar may be placed under a light for 24 hours.) At the end of the day or the next day remove the test tube from the jar which has been placed in the lighted conditions. To do this slip the test tube off the edge of the tag board. Put your thumb over the opening. Turn the test tube over carefully so that none of the trapped gas is released. To test for oxygen take a splint and light it on fire using a match, allow it to burn for a few seconds and then blow it out. Take the glowing splint and quickly place the splint over the mouth of the test tube. The splint will burst back into flames. Repeat the test for oxygen with the other test tube that was left in the dark.

Christian Application

God created plants to use carbon dioxide and produce oxygen. Animals and humans use oxygen and produce carbon dioxide. The two rely on each other to continue this cycle.

Extension

Prolonged space flights with humans would use a great deal of oxygen for breathing. How might the cycle be preserved in a small contained area? Design a system or invention to solve this dilemma.

CA

35. What Do You Need, Seed?

Equipment Needed

Half pint milk cartons (one for each child possibly), bean or radish seeds, potting soil, water

Purpose

To learn that plants require water, light, air, and soil to live and grow properly

Safety—Special Considerations

The children should wash their hands when the activity is completed.

Grade Level—Time Needed

Grades: K-8; Time: two class periods

Background

The plants will require air, water, soil, and light to remain healthy and alive. If plants do not receive these things, they will suffer.

Procedure

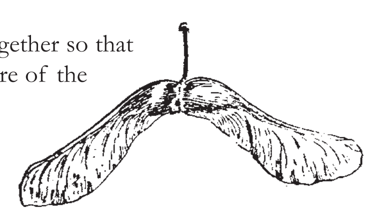
Cut the top off each milk carton and rinse the cartons out thoroughly. Fill the cartons with the soil and plant the seeds in the milk carton at a proper depth. The proper depth is usually three times the longest part of the seed. Moisten the soil so that all cartons are watered. After the seedlings sprout, divide them into four groups as evenly as possible. Each group will be put under different conditions. Group A: Plant has soil, water, and air but no light. Place these plants in a box or closet. Group B: Plants have soil, light and water but no air. These plants should have the cartons sealed in a plastic bag. Group C: Plants have soil, light, and air but no water. Do not water these plants. Group D: Plants have soil, light, air, and water. This group will serve as a control group. Each group should be measured in height at the beginning and the information recorded. Each week the plants of each group should be measured and the information recorded and graphed. After several weeks the group should compare the graphs and plants, then explain why each group of plants looks the way it does.

Assignment

Keep a record of the data from each group and make sure that the conditions are maintained. If plants are to be watered then be sure that they are watered, etc. (Proper watering allows the soil to dry between watering.)

Family Involvement

Each family may be encouraged to plant a flower box together so that they may enjoy the experience of ensuring the proper care of the plants as a family.



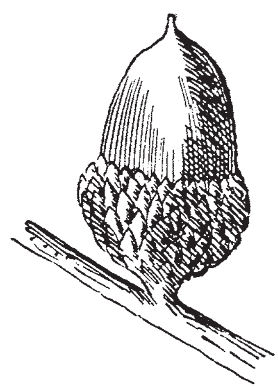
Christian Application

We should notice that the things required by plants to live and grow properly are provided for in creation. It is God who designed the plants with these needs and it is God who daily provides for these needs. Read Luke 12:22-31.

xtension

- Have the children take their plant home to care for it for 3-4 weeks and return at the end of set time period to show its growth.
- Introduce MECC's computer program *Lunar Greenhouse* (1989 edition not available through MECC but through other sources) and have children experiment on the computer.
- The lower grade teacher may wish to read *The Plant Sitter* by Gene Zion.

CA



36. Do Plants Need Light?

Equipment Needed

Board, black construction paper, stapler, healthy plant

Purpose

To conclude that plants require sunlight to grow, stay healthy, and stay green (produce chlorophyll)

Grade Level—Time Needed

Grades Kindergarten and up; Time: one class period and follow-up time

Background

Plants require light to conduct photosynthesis. Photosynthesis is a process by which the plants makes their own food. Thus a lack of light basically starves the plant of food.

Procedure

Place a board over a patch of grass for 7 to 10 days. After this time remove the board and observe the change in the grass. Staple black construction paper covers on top and bottom of individual leaves of a healthy plant. (*Caution: The staples should not puncture the leaf.)* After 7-10 days remove the covers and observe the difference between the leaves that were covered and those that were left uncovered.

Family Involvement

Small plants can be sent home with the children so the parents and children can repeat the experiment.

Christian Application

God uses the sun for more than heat and light. It is necessary for the preservation of all life.

Extension

- Observe the time it takes for the grass that had been covered to return to a normal healthy look.

CA

37. Plants Need Light

Equipment Needed

Two similar healthy plants, paper bag large enough to cover one plant

Purpose

To conclude that plants require sunlight to grow, stay healthy, and stay green (produce chlorophyll)

Grade Level—Time Needed

Grades Kindergarten and up; Time: one class period and follow-up time

Background

Plants require light to conduct photosynthesis. A lack of light starves the plant. The teacher should expect signs of stress in the covered plant. Note that the covered plant will grow to reach for light. Light inhibits growth causing the plant in the light to bend toward the light because the shaded side grows faster.

Procedure

Observe both plants and record the coloration of the leaves and general health of the plant. Place the paper bag over the one plant and allow the plants to remain in proper sunlight for 7 to 10 days. Emphasize that only one factor can vary (the light) in an experiment. After the time period, remove the bag and observe the differences between the plants and discuss why the differences occurred.

Assignment

Draw a picture of the two plants, showing the changes in growth and color.

Christian Application

God uses the sun for more than heat and light. The sun's light is essential for plants to live. We eat the plants or animals that eat the plants. This is necessary for preservation of all life.

Extension

- Observe the time it takes for the plants to once again appear equally healthy. Teach care and good stewardship.
- The teacher of the lower grades may wish to read to the class *The Plant Sitter* by Gene Zion (New York: Harper & Row, 1959).

CA

38. Are Plants Color Blind?

Equipment Needed

Two bean plants for each color to be tested (plants should be relatively the same size and age, about 14 days old), a box for each test group, light filters (colored cellophane)—clear, green, blue, red, yellow or any other extra colors, scissors, tape, and ruler

Purpose

To learn how the color of the light affects plant growth
To see that plants are not color-blind, but sensitive to color

Safety—Special Considerations

When students are cutting the boxes, they should exercise caution with the scissors or other tool.

Grade Level—Time Needed

Grade five and up; Time: one class period and follow up time

Background

Students should understand that the color of the filter indicates the color of light that will pass through. This can be demonstrated, if necessary, using a flash light as a light source and shining through a filter onto a white background. Remind the students that white light contains all colors.Most students will make the hypothesis that a green filter will be more beneficial for the plant. This is actually the worst choice. Plants, because of chlorophyll, reflect green light. They absorb the red and violet/blue light and use these wavelengths in photosynthesis. The filter will allow only that color of light to the plant.

Procedure

Remove the top and bottom of each box. Attach a light filter to one of the open ends of each box. Be sure that the soil for all the plants is moist and then place the boxes over the plants. Place plants and boxes so that equal sunlight shines into the tops of the boxes. Water plants regularly with the same amount of water. Observe and record growth of leaves and plant as a whole for four weeks. (The time can be extended to check for differences in fruit production.)

Assignment

Observe, measure, keep data for each plant every three days. Make graphs to show the growth development of the plants.

Christian Application

God provides for his creation in wondrous ways. Much of his work is unknown, unnoticed, or unexplainable even today. We can praise and give thanks to our omniscient God.

Extension

The same basic experiment can be performed using strawberry plants. The students can then make observations of plant fruit production and taste differences.

CA

39. Is More Carbon Dioxide Better or Worse?

Equipment Needed

Four healthy plants of similar size, straws or sticks, clear plastic bags large enough to go around the plants, string, tape, paper cups, effervescent tablets (Alka seltzer), scissors, two jars with one able to fit into the other easily, alcohol (80% ethyl), hot plate, water, pie plate, tweezers, iodine

Purpose

To learn that carbon dioxide is required for photosynthesis to occur

To conclude that plants can be encouraged to make more food by increasing the carbon dioxide available

Safety—Special Considerations

This activity requires the heating of alcohol. Alcohol is a very flammable liquid and should be handled only by the teacher. Extreme caution should be used when heating the alcohol in the water bath on the hot plate. Keep a cover handy in case the alcohol begins to burn. Put the fire out with the cover. Do not use water. Iodine is poisonous and will stain whatever it contacts. Students should wash their hands after using the iodine and effeverscent tablets.

Grade Level—Time Needed

Grades seven and up; Time: two class periods, twenty-four hours apart

Background

Plants require carbon dioxide for photosynthesis. Carbon dioxide, which makes up .03-.04% of air and reaches the interior of the leaf through the stomata, is considered to be the limiting factor for photosynthesis since it is the factor present in the smallest degree. The two plants in the light are growing under the same conditions with the exception of the extra carbon dioxide. The extra carbon dioxide will increase the rate of photosynthesis. The extra carbon dioxide for the plant in the dark will have no effect because plants also require light for photosynthesis. The iodine is a starch tester. A darker blue/black color indicates more starch. The plants store much of the sugar glucose made in photosynthesis as starch. A light brown color with the iodine test indicates a lack or low level of starch present.

Procedure

Push straws or sticks into the soil of each plant to prevent the plastic bags from laying on the plant leaves. Place two of the small plants inside separate plastic bags. Seal both bags with tape so that they are air tight. Place one in the light, and the other in a dark area like a closet. Place the other two plants into the plastic bags and locate one in the light and one in the dark. Before sealing the bags, place inside of the bag a cup half filled with water and two effervescent tablets. Do **not** put the tablets in the water yet. Seal the bags with tape so they are air tight. Working through the plastic bag, carefully pick up the tablets and place them into the water. Do not open the bags once the tablets are placed in the water until the end of the experiment. After 24 hours, the plants are ready to be tested for the amount of food produced. Open all the bags and remove the plants. Cut or break off one leaf from each plant being sure to label each leaf. To label you may make one small cut in leaf A, two small cuts in leaf B, three small cuts in leaf C, and four small cuts in leaf D. The teacher should place the leaves into the alcohol jar. Put this smaller jar into the larger jar with water in it. Be careful that the water does not overflow into the smaller jar or onto the hot plate. Set the jars on the hot plate and heat the alcohol to boiling. Students should note the color change taking place in the alcohol. The alcohol is removing the chlorophyll. After the leaves have turned white, remove the leaves with the tweezers. Rinse the leaves with tap water and set them in the pie plate. Pour the iodine on all the leaves being sure to cover them thoroughly. Allow the leaves to sit in the iodine for a few minutes and observe the color differences in the leaves. The darker colors indicate a greater presence of starch, the stored food made in photosynthesis. Students should draw conclusions based on the presence of starch and the location and conditions of each plant.

Assignment

Students should keep a record of data during the experiment.

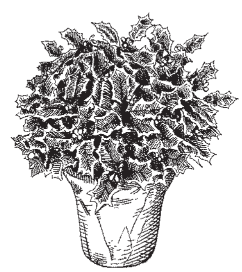
Christian Application

Why did God create plants so that they will grow faster with more carbon dioxide? Students should be reminded that God is almighty and omniscient. There must be a reason even if the students are unable to come up with a good explanation.

Extension

The number of tablets can be doubled or tripled. What are the results of these higher levels of carbon dioxide?

CA



40. Plants Need Air

Equipment Needed

Petroleum jelly, plant with many healthy leaves, labels, string

Purpose

To learn that leaves need air in order to produce food and live
To learn where air enters the leaves

Safety—Special Considerations

Petroleum jelly is not edible; children should wipe their hands on paper towels after applying it and not place their hands or fingers in their mouths.

Grade Level—Time Needed

Grades kindergarten—eight; Time: one class period and follow-up time

Background

Plants exchange gases through the bottom of their leaves through special openings called stomata. If they are stopped up, the plant leaf cannot get air. Just as lack of air is deadly for us, so it is for plants. Plants require CO_2 and O_2. They give off O_2 and H_2O.

Procedure

Smear the petroleum jelly on top of two leaves, on the bottom of two other leaves, on the top and bottom of still two other leaves. Make labels identifying what application was given and tie these labels loosely to the petiole(stem) of the leaf. Also make labels for two leaves that receive no petroleum jelly. After several days compare the leaves and draw conclusions as to whether plants need air and where on the leaf that gas exchange occurs.

Assignment

Record the color and appearance of each leaf before application of the petroleum jelly and also at the end of the experiment. Make a chart to show the changes.

Christian Application

God provides air for plants to use, rain to keep them clean. We need to be cautious about air quality for plants; we need to be careful not to dump things on plants or pollute them in any other way so that we are not the instruments of their deaths or extinction.

Extension

The same basic activity can be done using water, motor oil, cooking oil, or hair spray. Students can speculate on the outcome of using these products.

CA

41. How About a Good Meal?

Equipment Needed

Epson salt, 5-10-5 plant fertilizer, washing ammonia, water, four opaque gallon jugs (used bleach bottles), 8-10 day old bean plants, four jars (about quart size), vermiculite or perlite (quarter inch gravel will work in a pinch), ruler, straws or sticks and string

Purpose

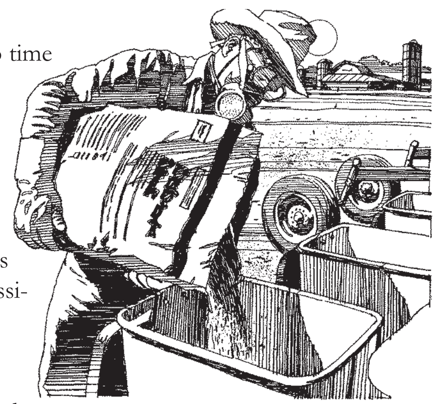
To learn that a proper mixture of nutrients must be present in order for plant growth and photosynthesis

Safety—Special Considerations

The hydroponic mixture should be labeled clearly. If children water the plants they should be careful that only the soil is watered. They should wash their hands when finished.

Grade Level—Time Needed

Grades seven and up; Time: one hour and follow up time



Background

The vermiculite or perlite provides no nutrients for the plants. It is used simply to support the roots and hold moisture. There are six elements that plants use the most. They are nitrogen, phosphorous, potassium, calcium, sulfur, and magnesium. Each of the nutrients has its own special function to carry out in the plant. For example, calcium is necessary for the formation of the cell walls and magnesium is required for the formation of chlorophyll.

Procedure

Emphasize that plants gain most of their mass from CO_2 in the air. The nutrients used in this activity are vital but are not the main source of material for growth. The teacher should prepare all liquid solutions prior to the class. The solutions are to be labeled A, B, C, D. Mixture A: one tablespoon of 5-10-5 plant fertilizer, 1 teaspoon Epsom salts, 1 teaspoon washing ammonia, mix with a gallon of water and store in an opaque container. Mixture B: same as A except no Epsom salt. Mixture C: same as A except use three tablespoons of 5-10-5. Mixture D: plain water. Tell students that each is a mixture containing different chemicals (water is a chemical also!). Use bean plants which are 8-10 days old grown in jar containing only vermiculite or perlite. These plants should be started in this medium and given only water to induce germination. (These may be the product of an earlier germination activity.) Place straws or sticks in as necessary and tie up plants for support. The children should label and record the measurement and coloration of all plants. An equal number of plants should be set aside into the four groups and labeled for watering as A, B, C, or D. Each group of plants should receive similar lighting (not direct, as algae may begin to grow). Water levels should be kept the same in the jar (about $1\frac{1}{2}$ to 2 inches below the ground level). The students should observe the plant's growth and coloration every third day for 4-6 weeks. At the end of the testing time, the students should decide which plant has grown best. Then the teacher should reveal the make-up of the hydroponic liquids used and encourage students to determine which nutrients are necessary for healthy plant growth.

Assignment

Groups of two or three students should keep detailed log books for each plant during the course of the experiment. Graphing growth can also be done by students to use as a comparison.

Christian Application

It is no accident that the necessary minerals are in the soil and attainable by plants. Making a plant live is no simple matter when we consider that the lack of a simple mineral can harm or kill a plant. How wise our Creator is.

Extension

The children can be encouraged to use the hydroponic method to grow a salad in the classroom. This is truly a special treat about January. Using various amount of the three basic materials in the hydroponic water can create a variety of experiments.

CA

Searching for words

At the 1996 fall meeting of The Association of Midwest College Biology Teachers, noteworthy text-writer, Ricki Lewis, told the biologists that attended her sectional about some of the problems in writing college biology texts. Now she no longer can use the words “creature” or “design” when writing about biology. The word, “creature” implies a Creator and “design” in nature implies a Designer. Reviewers have become sensitive to those words, she said. Another word that she cannot use is “abortion” which she says has become too emotionally charged.

42. Does an Annual Really Live Only One Year?

Equipment Needed

Bean seeds, five gallon bucket, vermiculite or perlite to fill at least half the bucket, dowel rods or sticks to support plants as they grow, hydroponic solution (see Background information for proper mixture)

Purpose

To determine if annual plants that produce fruit are bound to the seasons or other conditions

Safety—Special Considerations

The hydroponic mixture should be labeled clearly. If children water the plants they should be careful the plants themselves are not watered. They should wash their hands when finished.

Grade Level—Time Needed

Grades 5 and up; Time: one class period and periodic follow up

Background

Hydroponic mixture: one tablespoon of 5-10-5 plant fertilizer, one teaspoon Epsom salts, one teaspoon washing ammonia, mix in one gallon of water and store in an opaque container (used bleach bottle).

Procedure

Germinate the bean seeds in the hydroponic solution. As the plants grow, stake them up for support. Depending on how many seeds are planted, it may be necessary to thin some out for healthy growth. The bucket can be placed into a milk crate and sticks or rods tied to the crate. The water level in the container should remain at about 1 inch below the ground level. The students should keep a classroom log book with drawing and measurements of the plants on a weekly basis. When fruit begins to mature, harvest and weigh it. Keep a record of the mass of fruit produced and the length of the season for production of fruit. This information can be compared to a regular season and crop of beans planted under normal circumstances.

Assignment

Tend the garden and record events as they develop.

Christian Application

God has provided man with the ability to begin to understand plants and their life cycles. With that understanding and knowledge we can produce fresh fruit any time. How can we use this to give glory to God?

Extension

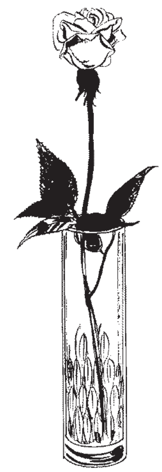
The same set up can be used to grow tomatoes or peppers. These provide interesting room decorations throughout the winter. This may become a two or three year activity under good conditions.

CA

43. Plant Nutrition

Equipment Needed

Several flowers (carnations work well), one can of lemon-lime soda, two aspirins, water, distilled water, sugar, bleach, five one-quart jars



Purpose

To learn that plants require nutrients in order to survive

Safety—Special Considerations

The teacher should handle the bleach. Bleach can burn skin and damage clothing and needs to be handled with care.

Grade Level—Time Needed

Grades 3-8; Time: one class period and some follow-up time

Background

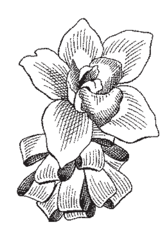
Plants produce sugar as an outcome of photosynthesis. This sugar serves as an energy source for the plant as it grows. Additional sugar generally aids the plant in its growth and maintaining a healthy look.

Procedure

Place two or more flowers into the jars. Label the jars as A, B, C, D and E. Jar A is to be filled with distilled water. Jar B is to be filled with plain tap water. Jar C is to be filled with tap water and throw in the aspirin as well. Jar D should contain tap water and two teaspoons of sugar. For jar E pour half a can of lemon-lime soda, half a can of tap water, and seven drops of bleach (to discourage algae growth). Students should record the appearance of the flowers at the beginning and make observations on a daily basis for four weeks.

Assignment

Continue the observations and record changes as directed.



Christian Application

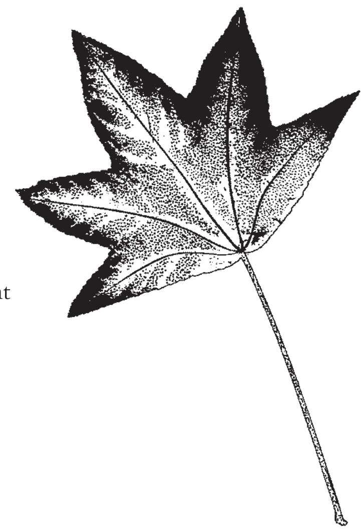
God makes the flowers grow and bloom. God has provided a wonderful method (photosynthesis) for these plants to live.

CA

44. What Makes Plants Green?

Equipment Needed

White construction paper, green leaves (tree)



Purpose

To identify what makes a plant leaf green

Safety—Special Considerations

Be sure that all the plant leaves are thrown away to prevent stains on the classroom carpet.

Grade Level—Time Needed

Grades Kindergarten-4; Time: 15 minutes

Background

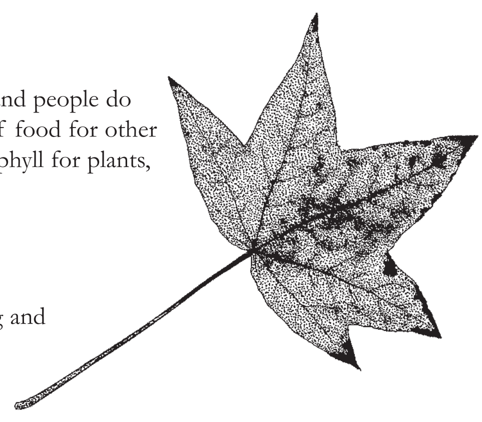
Chlorophyll is required and used by plants to convert sunlight, water, and carbon dioxide into sugar. This process is known as photosynthesis.

Procedure

Remove a healthy leaf from a green plant. Crush the leaf and smear it onto a piece of white construction paper. The green stain or streak left behind is produced by chlorophyll. This is also the cause of grass stains on clothing.

Christian Application

God made plants with chlorophyll. Animals and people do not have it. He uses plants to be producers of food for other animals and us. Without God's gift of chlorophyll for plants, life could not exist as we know it.



Extension

You may wish to use an old white sock or rag and stand on it in a grassy place. Then drag your weight on that foot so that a good grass stain develops. Have the children observe and explain what has happened.

CA

45. CO_2: In or Out of Plants?

Equipment Needed

Two elodea sprigs that have been kept in the dark for two days, water, 500ml flask or similar jar, five 250 ml flasks or similar jars, drinking straws, bromthymol blue solution (BTB), medicine dropper, scissors, ruler, tape, plastic wrap

Purpose

To observe that carbon dioxide is produced during respiration
To observe that carbon dioxide is used during photosynthesis
To reinforce the process of photosynthesis and respiration

Safety—Special Considerations

Whenever children use glass. caution and observe them closely. Tell them not to ingest BTB. Tell them to use caution when blowing through the straw into BTB solution. They should not inhale or blow so hard that they splash it into their faces. Students should wear goggles when blowing into the BTB solution. When the students are finished with the BTB, all those who came in contact with it should wash their hands carefully.

Grade Level—Time Needed

Grades 6 and up; Time: one hour

Background

Bromthymol blue solution is an indicator of carbon dioxide. In the presence of carbon dioxide it will turn yellow; when the carbon dioxide level decreases it returns to its blue color. The plants use the carbon dioxide during photosynthesis (in the light phase) and produce it during respiration (in the dark phase).

Procedure

Fill a small jar or flask with 100 ml of water and place 10 drops of BTB into the water. Stir the mixture with a straw until the liquid is uniform in color. Using the stirring straw, gently blow into the mixture until the color changes and is once again fairly uniform. Record observations and be able to explain why the liquid changed colors. Now take four of the jars or flasks and label them: *Light and Elodea, Dark and Elodea, Light and No Elodea, Dark and No Elodea*. Make a diagonal cut on two elodea branches removing the bottom half inch. Place the branches into the jars labeled as having elodea. Fill the large jar with 400 ml of water and add 40 drops of BTB. Stir with a straw until a uniform color is present. Pour 100 ml of the BTB solution into the jars labeled *Dark and Elodea* and *Dark and No Elodea*. Seal the containers with plastic wrap and tape them closed. Using a straw, blow into the remaining liquid until the yellow color is present throughout the mixture. Pour 100ml of this into each of the remaining two labeled containers and seal them just as was done for the first two. Place the containers labeled light in a bright place and those labeled dark in a completely dark place. After about 45 minutes bring the jars together and observe the color for each container. Record the data and draw your conclusions.

Assignment

Students may be asked to explain the results and document their reasons and rationale for believing as they do.

Christian Application

Plants can by themselves be sealed in a jar and remain healthy. God made plants to be recyclers. What they throw away in one step, they recall and use in the next phase of their lives. What a wise God to create such a self-sufficient chemically balanced system! There is great order to our created world.

CA

"He has done all things well ..."
Mark 7:37

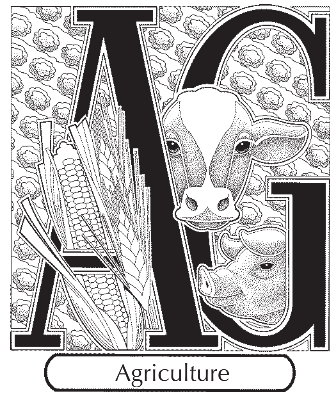
46. The Food Chain

Equipment Needed

Depending on level of project being done, could use old magazines or photographs for pictures, scissors, glue, yarn and pins, bulletin board

Purpose

To appreciate the food chain and its beginning with plants



Grade Level—Time Needed

Grades Kindergarten-6; Time: one class period

Background

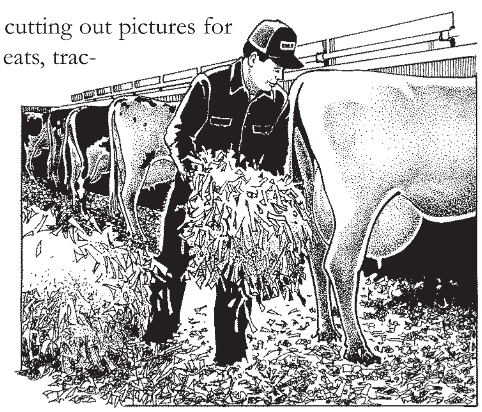
All animals and people will ultimately trace any food supply back to plants.

Procedure

Produce a bulletin board or other display using pictures or labels with animal and plant names linked together with yarn to show the direction of the food supply.

Assignment

The children should be engaged in finding and cutting out pictures for the display. They will explain what each animal eats, tracing the flow back to plants.



Extension

Parents can be enlisted to help find pictures with their children and to discuss the plant connection to our food supply.

Christian Application

God has provided for the crown of his creation with plants. We can give thanks for the simplicity and complexity with which he provides for us and his creation (cf. Gen 8:22).

Extension

Afterwards, the pictures plus additional ones can be made into individual charts. The children can even be encouraged to draw their own pictures for their charts. The charts can be laminated and used as place mats reminding the children of the lesson and application at their meal time.

Individuals or groups can be encouraged to study a plant at home or school and observe all the creatures that derive a living from it (worms, birds, bees, ladybugs, people, caterpillars, etc.).

CA

47. The Importance of Plants

Equipment Needed

Old magazines with photographs of plants, glue, scissors, one piece of 12" x 18" paper for each student

Purpose

To identify plants we use as food

Grade Level—Time Needed

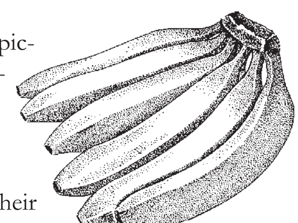
Grades Kindergarten—4; Time: one class period

Background

A great variety of food is derived directly from plants. Encourage the children to dig deep and think hard as they look for the pictures. For most it will be a very simple project.

Procedure

Students should cut out pictures of various plants used as food or pictures of fruits or vegetables produced from these plants. These pictures are to be glued to the paper in any manner desired. By doing this the students will have made a collage of plants we eat as food.



Assignment

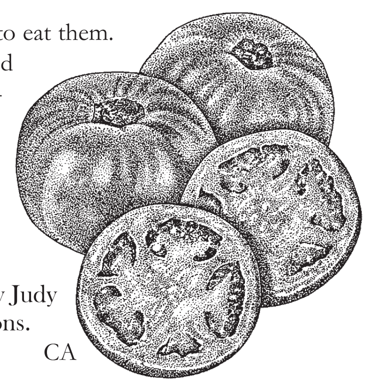
The students are to find a number of pictures and attach them to their papers. They may add titles to their papers such as, "O give thanks unto the Lord."

Extension

The family can be encouraged to help each child look for pictures at home. The family may also decide to try to eat an all plant meal one evening.

Christian Application

God made plants for Adam and Eve to eat. He told them to eat them. He still provides us with plants for food. We can thank God for this blessing and not avoid eating our fruits and vegetables.



Extension

- As a classroom activity, a snack can be prepared using only plants for food.
- The teacher may want to read *God's Plan for Plants,* by Judy Hull Moore and published by A Beka Book Publications.

CA

48. Johannes van Helmont's Mistake

Equipment Needed

Geranium plant, knife, rooting powder hormone, pencil, potting soil, plastic container (large yogurt or cottage cheese container), scale, distilled water, oven, metal baking pan, oven mitts, aluminum foil, small paintbrushes, and newspaper

Purpose

To gain an historical background to the study of plants
To learn that science can be wrong, but knowledge can still be gained

Safety—Special Considerations

During the course of the activity a knife will be used to cut off a piece of geranium. If children are to do this, they should be reminded to exercise caution and be well supervised. The soil will also be heated and dried in an oven. This will require adult supervision or adults to do the procedure at these steps.

Grade Level—Time Needed

Grades 5-8; Time: two class periods one month apart

Background

At the beginning of the 17th century very little was know about the growth of plants. This caused a Belgian physician named Johannes van Helmont to investigate plant growth. He designed an experiment to test his hypothesis that plants consist largely of water, and that, when a plant grows, its increase in mass results from the uptake of water from the soil and not from the soil itself. He tested this hypothesis in the following way: Johannes van Helmont dried 200 pounds of soil in an oven, placed it in an earthenware pot, and soaked the soil with water. He then planted a 5 pound willow shoot in the soil and left it for five years. He covered up the pot so that dust would not add to the weight of the pot over the five years. He provided only water for the little shoot as it grew. After the five years van Helmont again weighed the tree and the soil which he dried once again in an oven so water would not add to the weight. The soil weighed about the same as when he started, 199.8 pounds. The tree weighed 169.2 pounds! This led van Helmont to conclude that the entire tree had arisen from the water he provided. Even though we now know he was wrong, because 93% of the solid parts of a tree come from carbon dioxide as a product of photosynthesis and not from water alone, his experiment was significant. His work did show that soil was not the major source of plant mass. It led to the discovery of the process called photosynthesis.

Procedure

Step one — Planting

Preheat the oven to 400 degrees F. Fill the plastic container with soil and then empty the container on the baking tray in a thin layer. Place the tray and soil into the oven for 45 minutes. After the 45 minutes, carefully remove the tray; wear oven mitts. The soil should be dry, but if it is not, return it to the oven until it is dry. Allow the baking dish to cool. Weigh the plastic container and record its mass. Put the dried soil into the plastic container filling it within an half inch of the top. Weigh the plastic container with the soil. Record the mass of the container and soil and have the children calculate the actual mass of the soil. Add some water to the soil so it is wet but not quite waterlogged. Using a pencil, poke a hole into the soil about one inch deep. Any soil that sticks to the pencil is to be rinsed off into the pot so that no mass is lost this way. Use a knife to cut a piece with five or six leaves off the geranium. Remove the lowest leaf from the cutting and then weigh it. Dip the end of the stem into the growth hormone and place the stem into the pot. Gently press the soil around the stem and rub off any soil that may have stuck to your fingers. Using aluminum foil, cover the top of the pot and around the stem. Poke a few holes in the foil with the point of a pencil. Leave the pot in a sunny and warm location for 28 days. Every three days peel back the aluminum foil and water the plant as necessary. Do not water the plant in the last three days of the experiment.

Step two — Weighing

Preheat the oven to 400 degrees F. Place the baking dish on some newspaper and carefully remove the aluminum foil from the pot making sure that no soil is attached or lost. Gently grip the base of the stem and tap the bottom of the pot to loosen the soil. Carefully turn the plastic container upside down and lift the container away from the plant. Using your fingers remove the soil from around the roots so it falls into the baking dish. Use the paintbrushes to remove the finer particles clinging to the roots. When the plant is free from soil, set it aside. Brush off any soil particles from your fingers into the baking dish. Carefully brush out any loose soil from the container into the baking dish. Pour any soil that may have spilled on the newspaper into the dish. Now place the dish into the oven for 45 minutes or until the soil is dry. Weigh the plant and record its mass. Follow the same procedure for weighing the mass of the soil as used previously and record the data. (The geranium may by repotted to be enjoyed later.) Compare the results of your experiment describing any changes in the masses of the soil or plant over the 28 days.

Assignment

Maintain a data table for the project and water the plant as necessary.

Christian Application

God wants us to learn about the creation that he placed us in and provided for us. As we humans try to study and understand that creation, we sinful humans make mistakes. Fortunately for all of us, our God has never made a mistake. How great and wonderful he really is!

References

Historical Science Experiments on File, 1993, Facts on File, Inc.

CA

49. Receptors in the Eye

Equipment Needed

Colored pencils

Purpose

To demonstrate that humans have two types of vision receptors

To demonstrate that cones, the receptors that allow color vision, are concentrated near the center of the back of the eye

To demonstrate that rods, the receptors that respond to light intensity, are more widely distributed in the back of the eye

Safety—Special Considerations

Be careful not to poke anyone in the eye.

Grade Level—Time Needed

Grades 4 to 10; Time: 10 minutes

Background

Light reflected off objects in the front of the eye will focus on the center of the retina, which is rich in receptors called cones. This area is called the fovea. Colored objects in front of the eye will reflect light on the cones. The cones convert the light into a nerve impulse to indicate color. The reflected light from an object on the side of the eye focuses on areas of the retina other than the center. These areas are rich in rod receptors that are set off by low energy. The reflected light on the rods is registered as black and white. Even though the reflected light is the same, the retina in this area does not have many cones. Thus the colored object reflecting colored light does not appear as colored.

Scientific studies done in 1863 by Krause led to the acceptance of birds seeing color. Pumphrey (1948) established that there is very little difference between the color vision of birds and of mankind. Sturkie (1965) reported that all birds ordinarily active by day have color vision.

Procedure

A student stares at a distant point in the room. Starting behind the student's head, a partner slowly brings a colored pencil into the student's peripheral vision. The partner can give a slight wiggle to the pencil and then should stop moving the pencil when the student first sees it. Remind the student to continue staring at the distant point. Most often the student can see the pencil in his peripheral vision but cannot determine what the color is. Students can do this activity on their own by holding a number of colored pencils behind their backs and then randomly bringing one into their peripheral visions while they stare straight ahead.

Assignment

Students become the teachers and do this demonstration on family members.

Christian Application

The ability to see in color is a privilege God has granted to human beings. Imagine experiencing life in only shades of black and white. Most of God's other creatures do not see in color. Birds are the exception.

Extension

Explore types of color blindness and what causes them. Measure the degree of student peripheral vision.

References

Ehrlich, Paul R., David S. Dobkin, and Darryl Wheye. *The Birder's Handbook: A Field Guide to the Natural History of North American Birds*. New York: Simon and Schuster/Fireside Books, 1988.

Terres, John K. *The Audubon Society Encyclopedia of North American Birds*. New York: Knopf, 1980.

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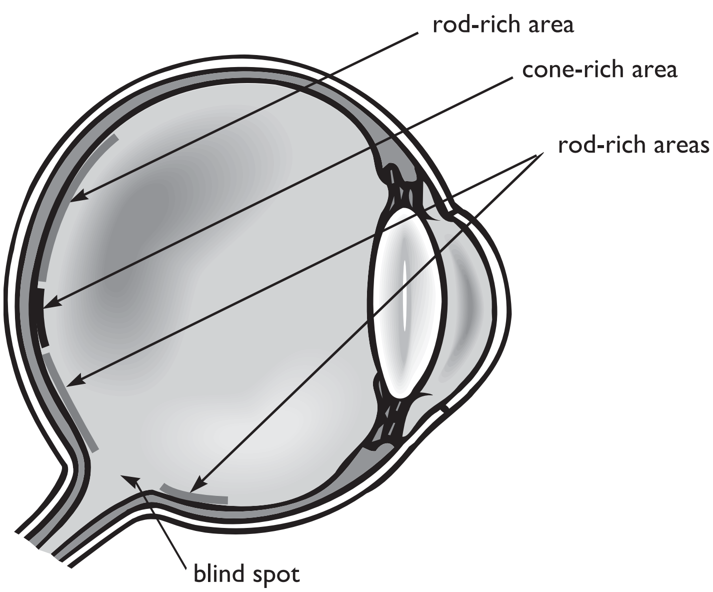


50. Bird Feeding Simulation

Equipment Needed

Individually wrapped bulk candy (e.g., Brach's peppermints)

Purpose

To simulate eating like a bird (you may not use your hands)

Safety—Special Considerations

Students will need some room for this activity. Doing this activity outside works well.

Grade Level—Time Needed

Grades K to 10; Time: 10 minutes

Background

Many seed-eating birds must first open the seed shells to get at the food inside. (e.g. Black-capped Chickadees and whole sunflower seeds)

Procedure

Scatter the candy about the room or the area outside. Explain that students will be simulating bird feeding. This means searching for food and opening the food once it is found. Students may not use their hands in any way to find or eat the candy. At the command, students are allowed to begin.

Assignment

Each student can choose a different species of bird and research that bird's food preferences.

Christian Application

God designed the human hand to perform in awesome ways. We miss our hands when we can not use them. Some humans lose the use of their hands and they must learn to compensate by using other parts of their bodies. Many of God's creatures use other parts of their bodies to survive in the wild. Consider how the beaks of birds vary according to the food they eat.

Extension

Different colors of candy may be used to demonstrate protective coloration. Some colors will blend in with the surroundings and be hard to find, others will be easy to find. Another variation is to put out only enough candy for some of the students. Some will go hungry who do not find food.

References

Ehrlich, Paul R., David S. Dobkin, and Darryl Wheye. *The Birder's Handbook: A Field Guide to the Natural History of North American Birds*. New York: Simon and Schuster/Fireside Books, 1988.

Terres, John K. *The Audubon Society Encyclopedia of North American Birds*. New York: Knopf, 1980.

MWT

51. Owl Pellets

Equipment Needed

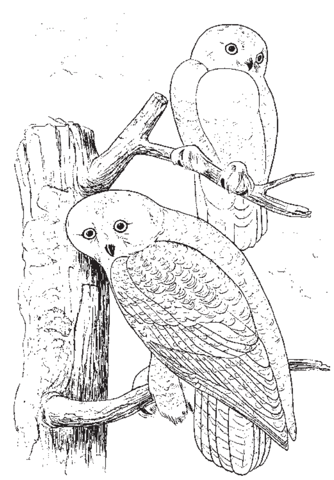
Owl pellets, forceps, teasing needles, hand lenses, metric rulers, white paper towels, zip lock bags for students who want to save skeletal remains

Purpose

To dissect owl pellets and identify the skeletal remains of the prey animals

Safety—Special Considerations

Owl pellets purchased commercially are fumigated, but students still should wash their hands when this lab is completed. Students should be careful not to touch their faces during the class. Remind students to exercise care in using forceps and teasing needles.



Grade Level—Time Needed

Grades 5 to 10; Time: 30 - 40 minutes

Background

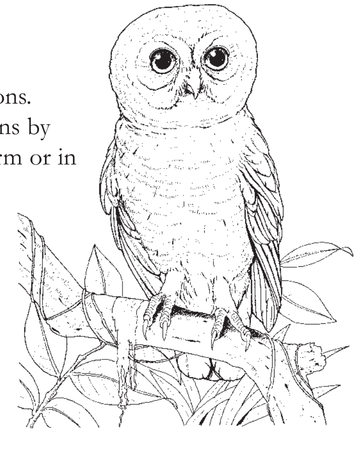
Birds that produce pellets include owls, raptors (hawks, eagles), and gulls. Owls swallow their food whole and digest all but the bones and fur or feathers. Undigested parts of the owl's food is regurgitated in the form of pellets. Owls that feed on insects regurgitate undigestible parts of numerous exoskeletons in their pellets.

Procedure

Unwrap the pellet and place it on a white paper towel (this provides a contrasting background as well as convenient clean-up). Measure and record the length and width of your pellet. Using the forceps and teasing needle, carefully pull at the fur and start to locate bones. Sometimes a small amount of moisture added to the pellet helps it come apart. Organize the bones. Use hand lenses and the illustrations that come with commercial pellets to identify the prey animal(s). Skulls offer the best clues for identification. Record the identities and numbers of animals found in the pellet. Dispose of the remains by wrapping them up in the paper towel or provide plastic bags so students may take the skeletal remains home.

Assignment

Students figure mean, mode, and median of pellet dimensions. Students looking for a challenge can reassemble the skeletons by gluing them to a piece of cardboard in two-dimensional form or in three-dimensional form.



Christian Application

God has created a variety of feeding behaviors among the class of animals we call birds. Each feeding habit has it own specialized means to separate the food stuffs and eliminate the wastes. The variety of feeding habits creates interrelationships of all organisms in any given ecosystem. Such a variety is God's way of protecting some organisms in the environment and providing food for others. This activity also allows observation of the God's design in the skeletons of small animals.

Extension

Students can find their own owl pellets on the ground beneath the roosting sites of owls. A natural extension is to study the small animals that owls eat.

References

Ehrlich, Paul R., David S. Dobkin, and Darryl Wheye. *The Birder's Handbook: A Field Guide to the Natural History of North American Birds*. New York: Simon and Schuster/Fireside Books, 1988.

Terres, John K. *The Audubon Society Encyclopedia of North American Birds*. New York: Knopf, 1980.

Source for owl pellets

Nasco
901 Janesville Ave.
Fort Atkinson, WI 53538
1-800-558-9595

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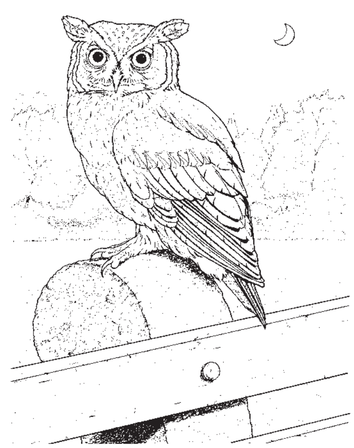


52. Feathers and Flight

Equipment Needed

Feathers, hand lenses, microscope, paper, long stemmed funnel, ping pong ball

Purpose

To examine feathers and to consider the basics of flight

Safety—Special Considerations

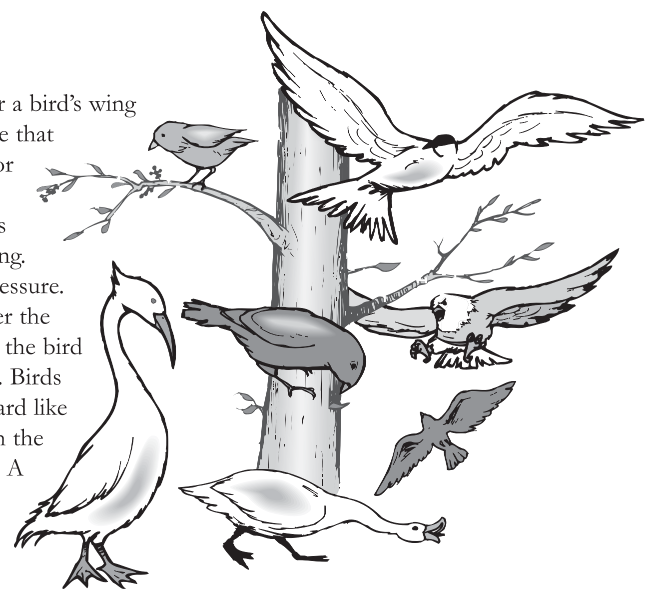
Students should wash their hands when this lab is completed. Chicken feathers may be available in bulk from art/craft catalogs or from poultry farms. Technically, it is illegal to have feathers of most wild birds in your possession unless you have a permit. Exceptions are the feathers of House Sparrows, Rock Doves (Pigeons), and European Starlings which are not protected by law.

Grade Level—Time Needed

Grades K to 10; Time: 20-30 minutes

Background

The air-tight feathers that cover a bird's wing give the wing a distinctive shape that is convex on top and concave or flat on the bottom. Air moving over the top of the wing moves faster than the air under the wing. Faster moving air exerts less pressure. Thus, the greater pressure under the wing pushes upwards allowing the bird to "lift" off the ground and fly. Birds generate "lift" by moving forward like a propeller-driven airplane, with the wings serving as the propellers. A Swiss scientist named Daniel Bernoulli first described this phenomenon of "lift" in 1738.



Procedure

Provide each student with a flight (contour) feather. Identify the parts of the feather. Carefully pull apart some of the barbs on the feather. **Do not** pull the barbs off the rachis (quill). *Consider what would happen to a bird whose feathers are like this* (loss of lift). Simulate preening by running the feather between thumb and forefinger. The barbs lock together again and are air tight. Create an air current by swiftly moving the feather back and forth. This air current can be felt near a person's face. Observe the feather with the hand lens. If available, a microscope slide of a feather fragment can be made and the interlocking barbules observed under a microscope.

To demonstrate Bernoulli's Principle of "lift," have students blow over the top of a piece of paper hanging limp between the thumbs and forefingers. Another way to demonstrate Bernoulli's Principle is to place a ping pong ball inside a long stemmed funnel. Blow through the stem of the funnel and the ball will not come out, even if held with the ball towards the ground.

Assignment

Research other design features birds have that allow them to fly. Research other ways feathers help birds survive.

Christian Application

God invented the original velcro when he designed the interlocking barbules on the barbs of a bird feather. In his design for different creatures God provided each organism with the equipment to live and survive in different environments.

Extension

Provide the opportunity for a paper airplane flying contest. Compete for greatest distance, longest hang time, most acrobatic, etc.

References

Ehrlich, Paul R., David S. Dobkin, and Darryl Wheye. *The Birder's Handbook: A Field Guide to the Natural History of North American Birds*. New York: Simon and Schuster/Fireside Books, 1988.

Terres, John K. *The Audubon Society Encyclopedia of North American Birds*. New York: Knopf, 1980.

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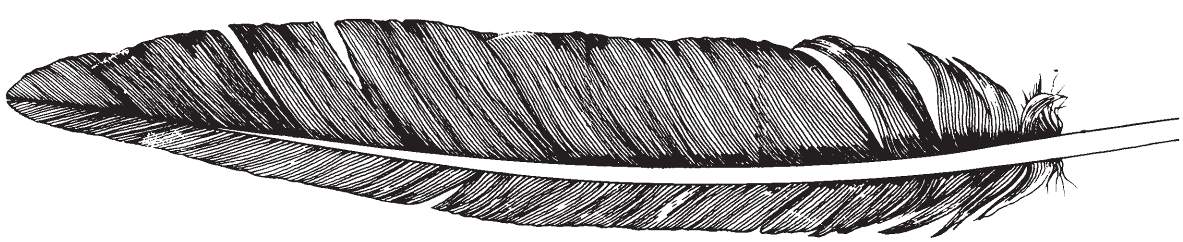


53. Camouflage—God's Gift to His Creatures

Equipment Needed

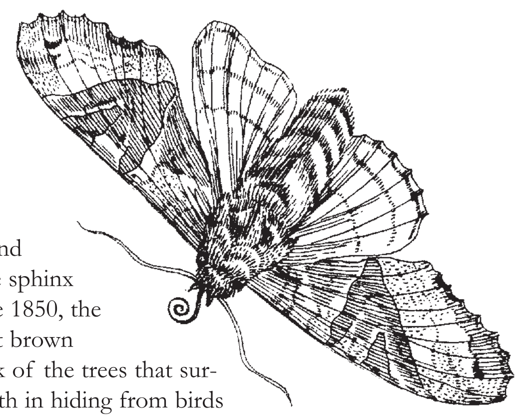
Newspaper; scissors; moth pattern; tape; green, brown, and white construction paper; graph worksheet

Purpose

The children will infer how the ability to blend into their environment is a wonderful blessing God has given to some creatures. The ability to camouflage is seen in many animals and, as in the case of the sphinx moth, is a contributing factor to their ability to survive.

Grade Level—Time Needed

Grades K-8; Time: one class session



Background

Examples of camouflage can be seen throughout the plant and animal kingdom. One vivid demonstration of camouflage and adaptation is seen in the population of the sphinx moth around Manchester, England. Before 1850, the general color of the sphinx moth was light brown which helped the moth blend into the bark of the trees that surrounded Manchester. This assisted the moth in hiding from birds that preyed upon it for food. During the Industrial Revolution in England the factories produced large amounts of smoke, soot and pollutants that changed the color of the vegetation, making it much darker. The light colored sphinx moth became easy prey for the birds. In 1848, the first black sphinx moth was found. Those following the sphinx moth population have noted that the segment of the moth population that survives is the one that matches its surroundings.This is called the process of natural selection. When light moths are easy to see, their population is eaten more frequently and goes down. While the dark colored moths can hide and live to reproduce. It is interesting to note that since the advent of more efficiently burning fuels, the light moth population is beginning to thrive again.

Procedure

- Prepare a background sheet of newspapers taped together ahead of time. Want-ads work the best for this activity.
- Use the moth pattern to cut a number of moths from each of the single sheets of paper, green, brown, white, and newspaper.
- Tape these moths to the newsprint background, doing your best to blend the newspaper print moths into the background.
- Conceal the entire "moth habitat" with a large sheet or piece of paper.
- Each student should be given the graph worksheet when the class begins. When the students are ready, they are to be given 10-15 seconds to observe the moth habitat and record the types and number of moths they saw. Cover the habitat back up.
- Compare the predictions among classmates. Ask the children which moths were the easiest to see and which were the most difficult to observe. What made them this way?
- Remove the cover on the background and help the students count all the moths.
- Graph the actual count.
- Share with the students the story of the sphinx moth.

Assignment

Middle to Upper Grades: Have the students look through books of different kinds of animals and have them find one they feel demonstrates camouflage. They should make a colored drawing of the animal and prepare to tell the class about this animal and its method of camouflage.

Primary: Give the students a white piece of construction paper and tell them to draw and color an environment. Then they are to cut out a moth from the pattern used in class and color it so that it blends into the environment they created.

Christian Application

God provided the members of the plant and animal kingdom with instincts, tools and adaptations to help them survive. The attention to detail that he shows in his creation demonstrates his love for all creatures.

Extension

The older students may wish to further research the story of the sphinx moth or other animals with unique adaptations.

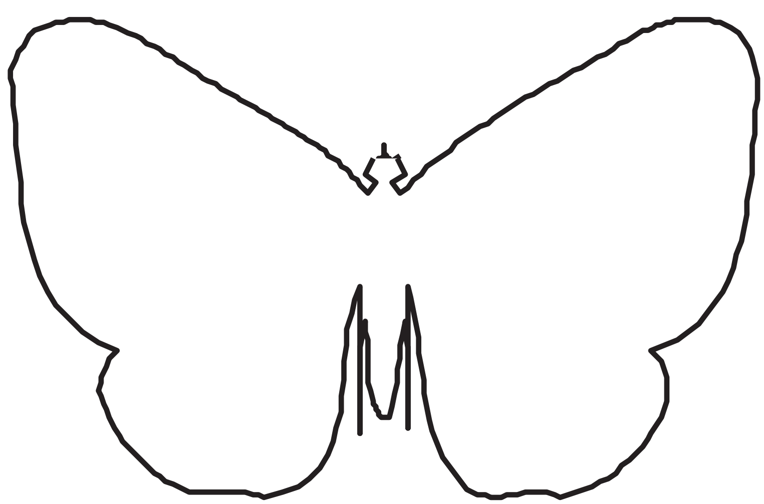
The class could make a large mural of a scene with all kinds of camouflaged creatures.

References

Hillen, Judith, Arthur Wiebe, Dave Youngs. *Critters.* Fresno, CA: Aims Education Foundation, 1992.

CFP

Moth Diagram



Camouflaged Moths

	A	B	C	D	E	F	G	H
21								
20								
19								
18								
17								
16								
15								
14								
13								
12								
11								
10								
9								
8								
7								
6								
5								
4								
3								
2								
1								

Use the gray box below to write the number you estimate or the actual number, then graph your results above.

	Green moth/ estimate	Green moth/ actual	Brown moth/ estimate	Brown moth/ actual	White moth/ estimate	White moth/ actual	Newpaper moth/ estimate	Newspaper moth/ actual

54. Collection of Invertebrates From Varying Micro-Habitats

Equipment Needed

Two-liter plastic bottles, 16 or 20 oz bottles, dark paper, duct tape, scissors, popsicle or craft sticks, lamp, jar with lid, 70% alcohol, water, ring stand, screening or a wire strainer

Purpose

The students will categorize the different kinds of invertebrates found in varying samples of soil. The students will be able to identify common characteristics of the various classes of animals found in the samples. The students will determine the factors that influence the animal life found in the micro habitats.

Safety—Special Considerations

The students will need to wash their hands following the collection of soil samples and after handling the invertebrates to prevent the spread of harmful bacteria. The invertebrates collected during this lab will need to be dead for classification purposes. Students should be instructed that when it is necessary to kill an invertebrate, Christian concern for God's creation should move us to handle it in the most humane manner.

Grade Level—Time Needed

Grades K-8; Time: two class periods—one for collection and one for classification. The Berlese-Tullgren funnel trap needs 24 hours to drive the invertebrates into the capture chamber.

Background

Invertebrates can be separated into many groups. The types of invertebrates the students will find in these samples will most likely come from these phyla. The Arthropod family includes spiders which are identified by their eight legs and two body parts: the head and thorax and the abdomen. They have no wings or antennae. Insects are also arthropods and are identified by their six legs and three body parts: the head, the thorax, and the abdomen. Generally insects also have wings and antennae. Millipedes and centipedes also belong the arthropod phylum. The Annelid phylum may also be represented by the presence of various round or segmented worms.

Procedure

Construction of the Berlese-Tullgren Funnel Trap

- Cut off the bottom of a 2-liter bottle. You will use the part that resembles a funnel.
- Measure and cut three popsicle sticks two cm shorter than the diameter of the bottle.
- Stack the three sticks on top of each other and arrange them so that the angles are about equal between them. Tape them together. They should fit inside the funnel slightly above the curve bottom of the bottle.
- Tape dark paper around the 16-20 oz bottle being sure to allow no light inside. Add 20 ml of water to this bottle.
- Place the funnel set up into the ring stand. Tape the mouth of the 16-20 oz bottle to the mouth of the funnel.
- The funnel part of the trap will hold the soil litter sample. Position the light over the bottle.

Sample Collection

Chose several micro habitats from which to gather your samples. Some suggestions would be grassland, deciduous and coniferous regions. Scrape the soil litter from the sample area into a labeled plastic bag. Include a light layer of soil along with the litter. Label the funnel to identify the soil sample it will contain and place the sample in the funnel over the popsicle sticks. Place the light over the funnel and leave the light on for 24 hours. The animals will fall into the water below and will be available for counting after the 24 hours. Use the screen to strain out the animals from the water. If the invertibrates are not dead when you remove them from the trap, have a jar (with a lid) half filled with 70% alcohol and transfer the animals into this jar.

Assignment

The students should separate the invertibrates by similar characteristics: number of or presence of legs, antennae, wings, etc. A data sheet for recording and then graphing this information is attached.

Family Involvement

Students could enlist their parents help in the collection of a sample from their home. The students could compare invertebrates found in their varying locations and could consider what factor may have affected what they found.

Christian Application

Of all animal populations the insect world is the largest. Yet our Creator knows each one of these creatures by name. What a comfort to us that the Lord knows us and calls us by our names. He will not let anything happen to us that is not his will.

Extension

After completing the basic graphing of animals found, the children could draw and color their animal as well as classifying it or labeling its basic body parts. The teacher could make a large Venn diagram using hula hoops or ropes and the children could practice classifying the animals in different ways. For example, the different circles could be labeled *Antennae* and *Wings*. The overlap in the circle would contain those creatures having both antennae and wings.

The children could build an insect or spider using clay and toothpicks, demonstrating the body differences between the animals.

The children could mount their animals into a collection. Various methods for mounting include using straight pins and mounting into Styrofoam, cork, or cardboard.

References

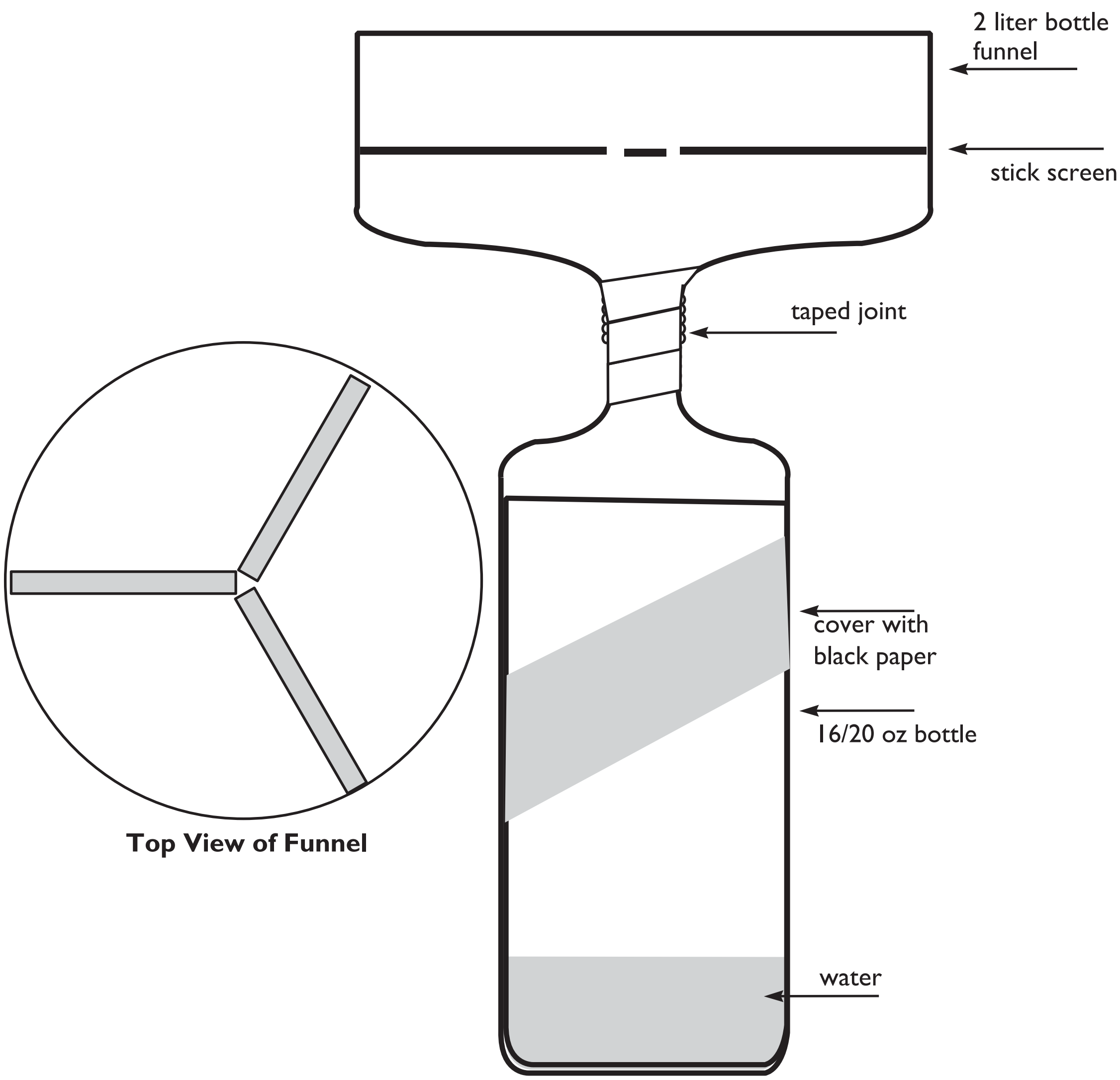
Hillen, Judith, Arthur Wiebe, Dave Youngs. *Critters*. Fresno, CA. AIMS Education Foundation, 1992

Frey, John, Margaret Kelly. *Soil Ecology-Activities for Middle School Curriculum*. Mankato, MN: Mankato State University, 1994

Jaques, H.E. *How to Know the Insects*. Dubuque, IA: WM. C. Brown Company, 1947.

CFP

The Berlese Tullgren Funnel Trap



Capturing Critters

Soil sample type: ______________________

	A	B	C
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24			
23			
22			
21			
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16			
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1			

Use the gray box below to record the numbers, then graph what your found above.

	Insects	Spiders	Worms

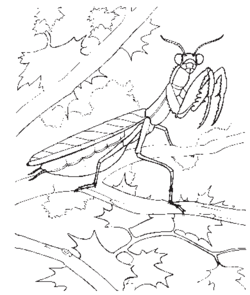
55. Following in the Footsteps of an Entomologist or How To Be a Bug Scientist

Equipment Needed

Supplies for the construction of insect models: no-bake clay, toothpicks, buttons, seeds, construction paper, tissue paper, yarn, pipe cleaners, shoe boxes, and insect identification books that show the different kinds of appendages and body parts insects may have.

Purpose

To learn about a real entomologist and go through the steps of identifying a make-believe insect



Safety—Special Considerations

Directions for no-bake clay vary. Adjust this activity as needed based on the type of clay you are using.

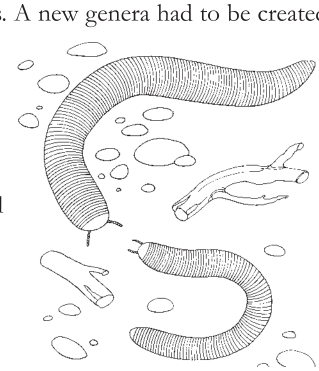
Grade Level—Time Needed

Grades K-8; Time: The time necessary for the no-bake clay to dry will vary based on manufacturer's directions. Several class periods will be needed to create, paint, and label the insect and its mini-environment.

Background

In 1955 an unknown butterfly was caught by an entomologist named Felix Woytkowski in a jungle in Peru. The butterfly, which was named in part for him, is known as the *Pectinobotys woytkowskii*. In his many expeditions to Peru from the year 1929 until his death in 1966 he collected more than a thousand previously unknown insects. A new genera had to be created for some of the insects. Some of his specimens are still in museums waiting to be studied. He also collected samples of the fauna on his trips.

Scientists who study the rain forest feel that only a small percentage of insects that live there have been classified and named. Perhaps the answers to some of our medical concerns lie in the creatures yet to be discovered. Today's students could make great discoveries.

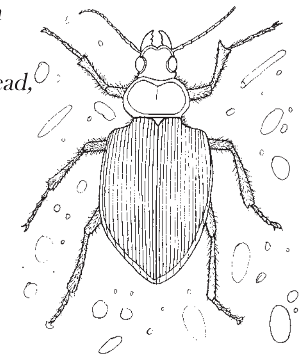


Procedure

Share with the students the mini-biography of Felix Woytkowski. Tell the students that they are off on an expedition to the tropical rain forests of South America. One of their insect traps has captured an insect that appears to be unclassified and unnamed. As the discoverer of the insect their name will appear after the genus and species listing. For example, the dog tailed dragon fly is named *Tetragoneuria cunosura* (Say) because Say first identified this insect. The mythical insect the students will create is the *Acerentulus domestica* [a ficticious name] (student's name). The students are to construct a model of the insect out of no-bake clay and paint it after it has dried. The students should answer the following questions as they model their insect:

- *What kind of mouth part does the insect have? chewing (like teeth), sucking (like a straw) piercing/sucking (like a pointed straw that pokes and then sucks), or sponging/lapping (like a sponge or tongue)*

- *Does my insect have wings? If it does, are they long and slender, rounded, pointed etc.?*
- *Does my insect have antennae? If it does, are they long and thin, feather-like etc.? How many do they have?*
- *What do the legs of the insect look like?*
- *How many eyes does it have and where are they located on the head?*
- *What are the size and shape of the three body parts: the head, thorax and abdomen?*



The students should indicate and label the body parts and appendages. The students should also construct a diorama representing the environment of their insect.

Assignment

The completed insect and diorama should be evaluated for neatness, completeness, and creativity.

Family Involvement

Inquire if any of your school families have a personal insect collection which they might share with your class. Perhaps some of your families have insect identification key guides that they could also share. A parent volunteer could video tape each child showing his/her insect and describing his/her adventures in finding this new animal.

Christian Application

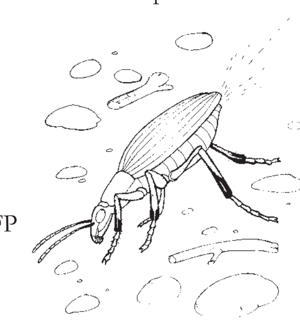
The vastness of God's creation amazes us each and every day. How much we have yet to discover of his handiwork.

Extension

Have the children write a journal or diary of their travels to the jungle and how they found their animal. They could describe the insect in detail and tell how it eats, whether it bites, if it is poisonous etc. These stories could also be read aloud by the children and videotaped.

References

Woytkowski, Felix. *Peru, My Unpromised Land*. Washington, DC: U.S. Department of Commerce, 1974.



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56. Observation of the Life Cyle of an Insect

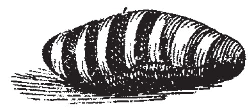
Equipment Needed

Meal worms, a plastic container or shoe box, dry cereal or oatmeal, a log book

Purpose

The children will learn about the four stages of growth in insects. Insects undergo change or metamorphosis as they move through egg, larva, pupa stages to become adults. The students will learn the special needs of each stage and will observe the molting necessary to keep growing.

Safety—Special Considerations



Meal worms can be purchased from a local pet store or bait shop. The children should be careful to wash their hand after handling the meal worms to prevent the spread of bacteria. The children should be given responsibility for their own meal worms and should understand the things the meal worms will need to survive. The meal worms should be released outside when this lab is completed and not thrown down a drain or into an inside trash container.

Grade Level—Time Needed

Grades K-8; Time: The cycle of the meal worm will last anywhere from 6-8 weeks. The children will need to observe and chart the changes in their meal worms each day.

Background

Most insects go through several stages of growth. In complete metamorphosis the four stages are egg, larval, pupal, and adult. Meal worms are the larval stage of the common grain beetle. The eggs of the beetle usually hatch in about one week. The hatchlings, or larvae, are voracious eaters and soon need to shed their too-small skin. This process is called molting. The larval stage continues for 2-3 weeks during which time the meal worm will shed its skin several more times. The next stage of development lasts about one to three weeks and is called the pupal stage. During this time the animal resembles a bent little finger and appears dormant. When the adult beetle emerges from the pupa case, it is white, then turns brown and finally black. It hops about 10-12 cm and has wings, but it cannot fly. The female can lay up to 500 eggs before it dies.

Procedure

The children should prepare their meal worm home by obtaining a small plastic container such as cottage cheese or yogurt. The cover to the container should have several holes punched in the lid. Some damp cereal or grain inside will provide food and cover for the meal worm. The children should draw their meal worm, measure and record its length in their logs. The children should observe their meal worm daily and record what they notice. Some days there will be no changes. When an obvious change occurs, the children may add a drawing to record this change.

Assignment

The children's record log will be an ongoing assignment for this activity. The children should have dated entries for each day they recorded observations.

Family Involvement

The parents will be notified at the beginning of this lab and could provide the containers and food supply for this lab.

Christian Application

In Genesis, God commanded all animals to be fruitful and multiply. God gave the insect world a distinct way of reproducing as seen in the metamorphosis or life cycle of the meal worm. To see his handiwork in a creature so small tells us he also works his will in the lives of his greatest creation.

Extension

It is possible to purchase silkworm eggs from science supply stores and if you have access to a nearby Mulberry tree, you can observe the 4 stages of the life cycle in the silk worm. The care of silkworms is different from that of the meal worm. They must have fresh mulberry leaves daily and the dried leaves must be removed. The silkworm will need a small branch on which to spin its cocoon. Once the female moth hatches, it will mate, lay between 300-500 eggs and die. These eggs can be stored in a container and refrigerated for the next spring. An interesting observation for silkworms is to measure how long they grow from a beginning larvae to one just ready to spin its pupae. A correlation between availability of food and growth could also be tracked.

You may also wish to record the stages of the life cycle by photographing the stages and having the children write about each stage or by videotaping the changes and having the children report about the changes on the video tape.

Students could research other insects that go through metamorphosis and determine which cycles would be complete metamorphosis and which would not.

Students could also experiment with different environments for the meal worms and determine which environments they like best and which they like the least.

Eggs can be ordered from Insect Lore Products, Inc. Box 1535, Shafter CA 93263 or by phoning them at 1-800-LIVE BUG (548-3284)

References

Hillen, Judith, Arhtur Wiebe, Dave Youngs. *Critters*. Fresno, Ca. AIMS Education Foundation. 1992.

CFP

57. Fingerprints

Equipment Needed

Water-soluble ink pad, paper, corn starch for dusting powder, clean glass or smooth surface

Purpose

To demonstrate the purpose of fingerprints
To show that fingerprints are unique for an individual

Safety—Special Considerations

Exercise normal care with ink to avoid getting it on things that should not be stained.

Grade Level—Time Needed

Grades 4-6; Time: one class period

Background

No two people have identical fingerprints. Even identical twins have differences in their fingerprints due to differences in cell growth patterns. The chance of any two people having the same fingerprints is estimated to be less than one in a billion. The pattern is determined by genetics and environmental effects. Several genes (which is called polygenic inheritance) in combination with the movements that the fetus makes at about six weeks into gestation cause the patterns. Because the environment is involved, geneticists call the trait multifactorial. The purpose of fingerprints is to help us hold on to things. However, because they are different, fingerprints can also be used to identify people. There are four basic types of fingerprints: (1) the loop, (2) the arch, (3) the whorl, and (4) accidental. The loop design is the most common. It begins on one side of the finger, curves back sharply and goes back to the same side. The arch has ridges that go from one side to the other, rising in the center. The whorl is circular. There are subtypes of these first three groupings. If the prints cannot be classified as one of these, they are called accidental, meaning that they have no specific form (cf. "fingerprints" in *World Book*).

Fingerprints have their origin at the top of the dermis layer of skin in ridges called pappili. To remove fingerprints a person would have to remove the epidermis layer and damage the pappila at the top of the dermis.

The feet also have strong ridge patterns. Babies are foot printed for identification at the hospital after they are born. The fingers are not used because babies suck their fingers.

Technology to scan a person's fingerprints into a database, along with a digitized mug shot and other information is becoming more common.

Procedure

Ask the students to look at their hands and fingers. *What do you see?* (small ridges)

Have the students place their hands with palms up on their desk and try to hold on to the table top. Now try this with palms down. *Why there is a difference?* (The fingerprints increase the friction and grip the surface of the desktop.) *Why has God given us fingerprints?* (To help us hold on to things.)

Have the students place their fingerprints on a glass. Lightly dust the glass with corn starch. Blow off the excess starch and examine the prints. Can you see the ridges? You might want to try this on your overhead projector and project the results to the entire class for discussion but take care not to press so hard that the glass surface of the projector breaks.

Next tell the students that they are going make prints of the ridges on their fingers. Distribute ink pads or have them come to a table where the pad is. Roll each finger on the ink pad and have them roll each inked finger on the paper. Make two copies. Wash the fingers immediately.

When the prints are dry, have the students hand one sheet in to the teacher. The teacher should number these and separately record the identity of each. Meanwhile, the students should classify their prints on the other sheet as loop, arch, whorl, or accidental. Have the students write the classification on the paper. They should also put their name on the second paper. Post the fingerprints in groups on a bulletin board.

Now distribute numbered copies of the prints to the students. Ask them if they can match these prints to those on the bulletin board. (Some prints may not be clear enough but some matches should be possible.) When students think that they have a match, have them write the name of the person on the numbered copy. Announce if they are correct in their identification.

Next ask the students if they know any identical twins. Identical twins occur when a single fertilized egg divides into two separate organisms. This type of twinning produces individuals with the same genes. If there are identical twins in the classroom, investigate to see if their fingerprints are identical. (They are not. Their genes are the same but their early movements would be different, causing different patterns.)

Assignment

Describe the skeletal parts of some of the animals and tell how they made it possible for the animal to perform certain functions.

Family Involvement

Take the fingerprints home and have the family place them in a safe place.

Christian Application

God knows each one of us as a special individual. He knew us before we were formed in the womb of our mother (Jer 1:5).

Extension

The number of ridges in the loop pattern can be counted. Consistently count from the center (A) to landmark (B) at the edge of the loop (see following page). A ridge must cross the line from A to B to be included in the count.

References

Integrated Automated Fingerprint Identification System (IAFIS). "What is IAFIS?" n.d.

Lewis, Ricki. *Human Genetics: Concepts and Applications*. Dubuque: William C. Brown, 1997, pp. 6, 124-5.

Mendenhall, Gordon, Thomas Mertens, and Jon Hendrix. "Fingerprint Ridge Count." *The American Biology Teacher*. 51(April 1989):4, pp. 204-6.

Sinha, Gunjan. "The Right Touch," <http://www.sciam.com/0896 issue/0896 techbus03.html>, August 1996.

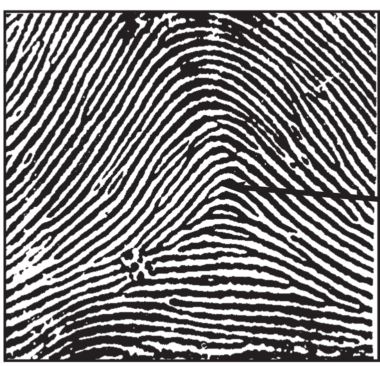
Thornton, John I. "Fingerprints." *The World Book Encyclopedia*. Chicago: World Book, Inc., 1993, vol. F (7), 106-7.

AD and PRB

Types of Fingerprints

The Loop:
the most common type of pattern

The Whorl:
a circular pattern



The Arch:
a pattern which rises in the center

The Accidental:
a type of whorl which combines other patterns

58. Dinosaurs—Methods in Paleontology

Equipment Needed

Drawings of skeletal parts from various animals, glue (optional). You may wish to provide other dinosaurs or other animals if it fits your purpose.

Purpose

To be able to differentiate skull, rib/rib cage, pelvic bone, breastbone, and other portions of a skeleton. Students will experience the challenge of putting a skeleton together. They can also be challenged with understanding the specific functions of certain skeletal parts of specific animals. They should grow in their appreciation of the work of the paleontologist.

Safety—Special Considerations

Exercise normal care when using scissors. Before copying skeletal parts for students to cut out, you might want to make a dotted line around each generally outlining it as a guide for cutting. It should be explained to students that these will be two-dimensional side views of skeletons. Therefore some parts will have to be hidden when the skeleton is assembled. A part may overlap or be hidden by another. They do not fit together like pieces of a puzzle. Some parts that occur only on the hidden side may be absent from the drawing.

Grade Level—Time Needed

Grades 4-8; Time: one class period per skeleton

Background

Size, shape, and structure of bones tell us something about the strength and abilities of animals as well as providing information about the size and shape of the animal. A large forward extension of a breastbone may suggest flight. Large bones may suggest strength. Light bones/hollow bones are characteristic of birds. Teeth are a clue to diet (carnivore, herbivore, scavenger), a tail may have functioned for balance, defense, communication. It is beneficial for the instructor to make some observation and know some of those functions in preparation for the activity. Dinosaur skeletons are compared with similar skeletons of existing animals. Similar shapes suggest similar functions.

Procedure

Review the general structure of the skeleton using a drawing of a human. Tell the students that God often used similar designs when creating different animals: "same designer—same design." That is, if God had a good design for the ribcage, he used it, perhaps with modification, in the design of other creatures that needed the same light-weight, flexible support and protection. This understanding is a tremendous blessing in the areas of anatomy, physiology, genetics, medicine, and other sciences where the form and functions of animals can tell investigators much about humans.

When scientists find a skeleton, they may not be fortunate enough to find all of its parts. Often the skull may have rolled away and may be difficult to find. The skull is an important find because it tells so much about the animal. The type of teeth indicate what the animal ate. Recently, scientists have even been able to estimate the power of a Tyrannosaurus rex bite by looking at the punctures and tears on the remains of a Triceratops skeleton, which apparently was a favorite meal of T. rex. A model of a T. rex tooth was made and marks were made on cow bones while the force was measured. The force behind each tooth was equivalent to "the weight of a pickup truck" stated Gregory M. Erickson, a graduate student investigator at the

University of California, Berkeley.

The location of the eyes indicate if the animal was predator or prey. Predators have their eyes close together allowing good depth perception for the capture of prey. The fox is an example. Prey have a wider field of vision to allow them to watch out for predators; thus, their eyes are located far apart. The rabbit is an example. The size of the cranial (brain) cavity indicates the size of the brain.

After that introduction, provide cut-out parts of various animal skeletons for groups of students, or have them cut out their own. Students should identify the part of the body to which each belongs and its name if possible. Then the parts should be placed on a sheet of paper to show the complete skeleton. Once assembled, students should try to identify the animal. Pieces may be glued down permanently if students cut out their own from provided copy, or they may simply lay them out if they are printed on heavy stock or laminated for reuse. Students who have difficulty or want to check their results can be given pictures of whole skeletons. Students can then see that the paleontologists have an easier time assembling bones if they have an existing skeleton to use as a guide for identification. Circulate among students asking questions about how skeletal parts attach to one another, what is useful knowledge for the paleontologist, what some of the skeletal structures suggest about the animal.

Assignment

Describe the reconstructed animal and tell how the skeletal parts made it possible for the animal to function. *What kind of an animal is it?*

Christian Application

Mathematics and physics are involved in skeletal design. Appreciate God's ability as an architect and engineer. Consider the design of behemoth in Job. 40: 15-24, esp. v. 18, and how God calls this animal first among his animals. Behemoth, which means "large animal" may have been a dinosaur. We have no way of knowing, however. Behemoth is an example of the limits of human knowledge and control.

Extension

Work with dinosaur skeletons.

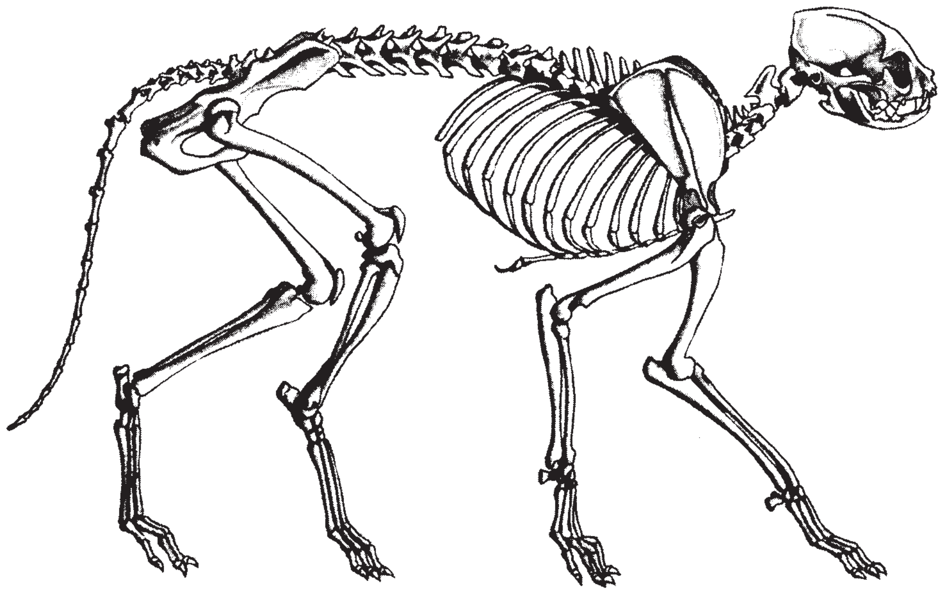
References

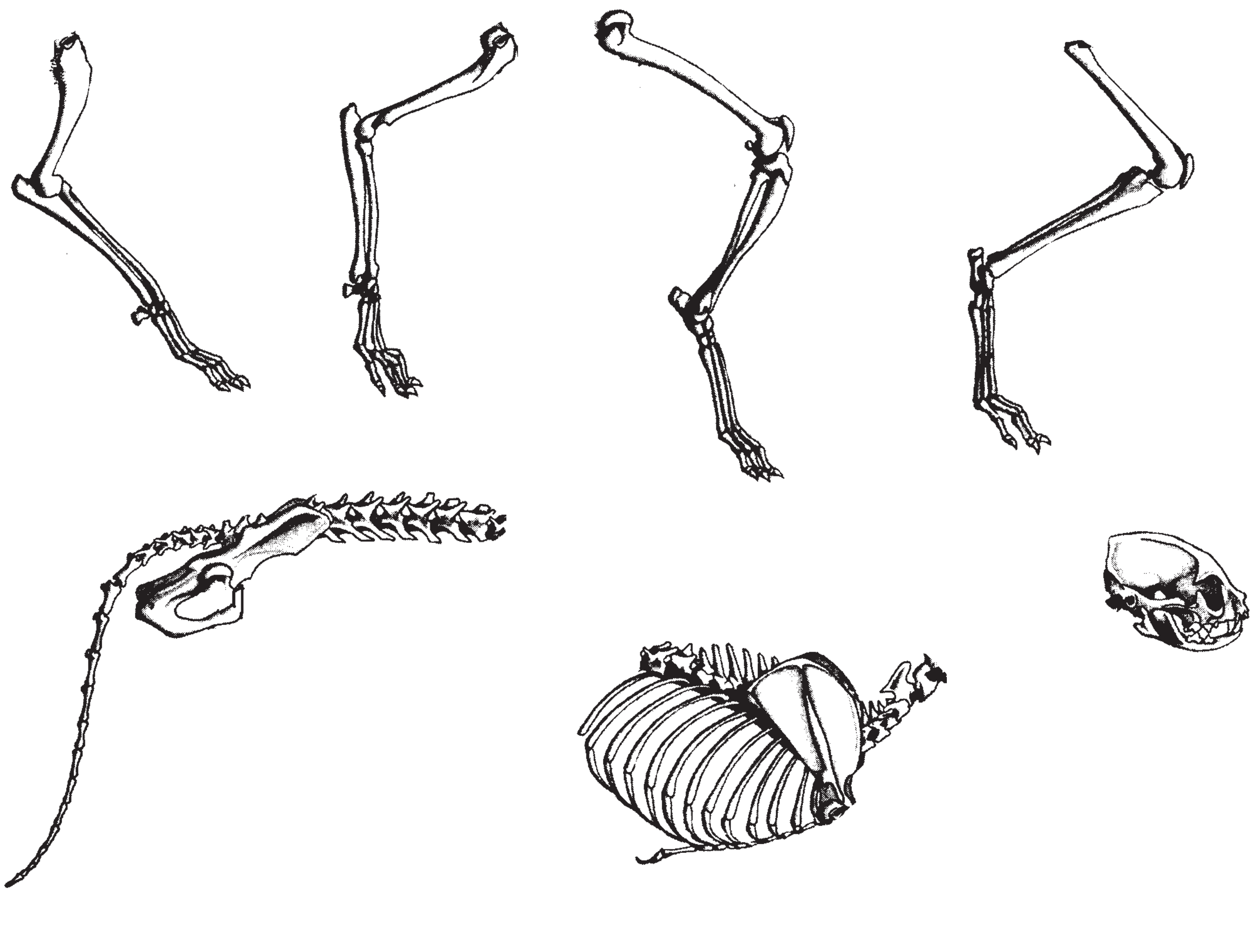
McDonald, Kim A. "Study Shows T. Rex Had Powerful Bite." *The Chronicle of Higher Education.* September 6, 1996, A25.

TK

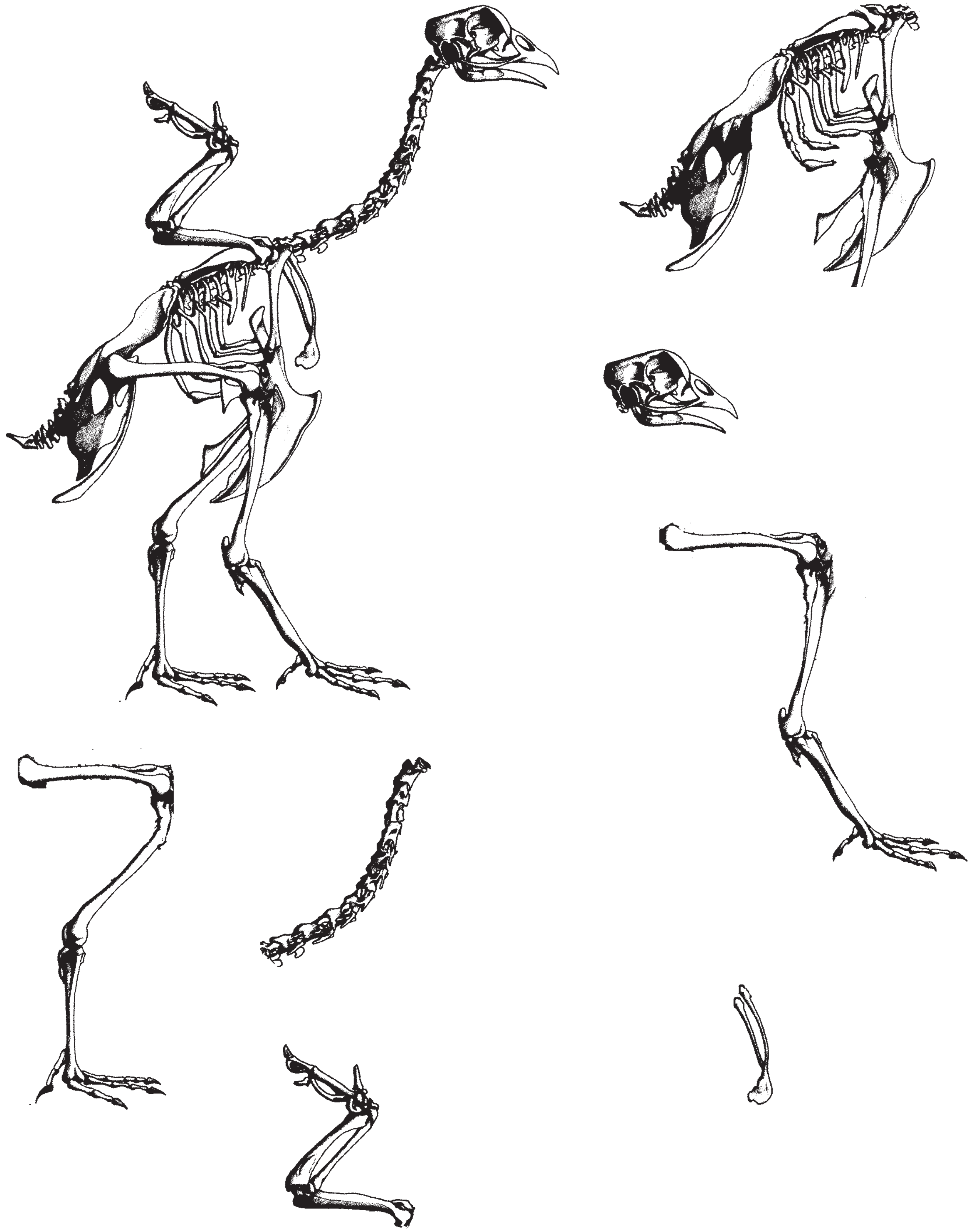
God often used similar designs when creating different animals: "same designer—same design."

Worksheet Lesson 58





Worksheet Lesson 58



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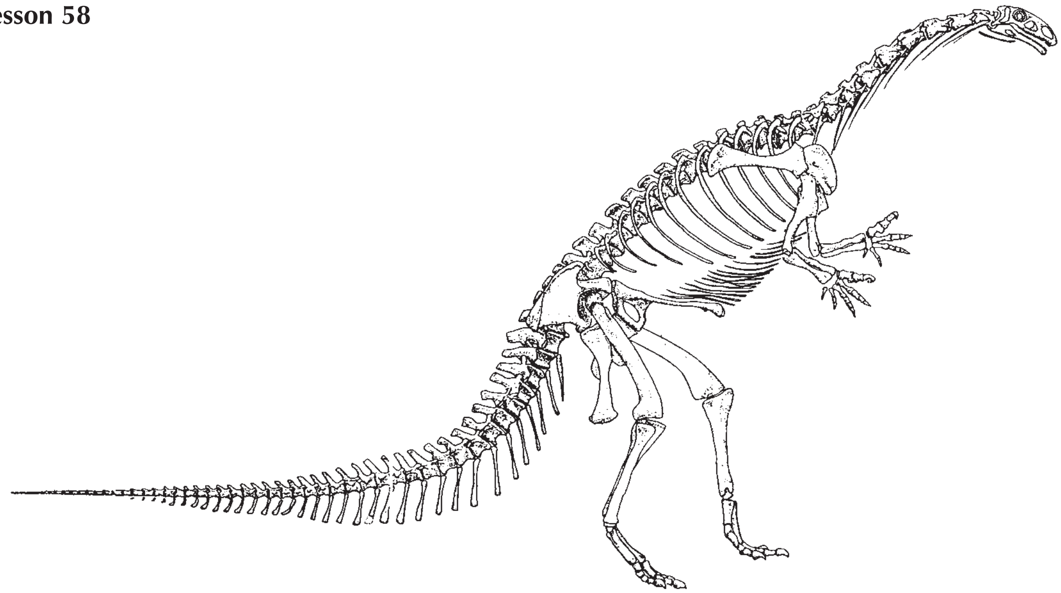

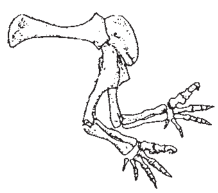

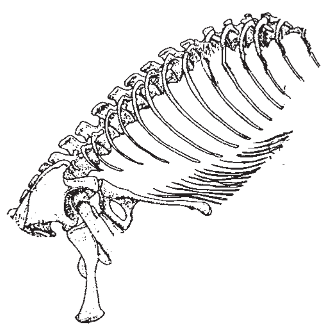

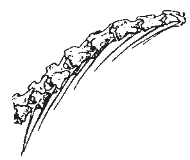

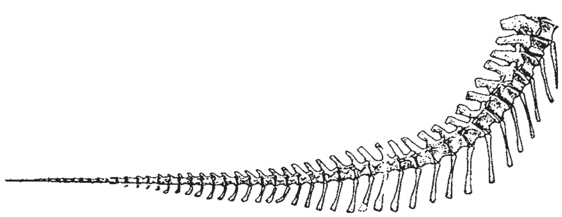

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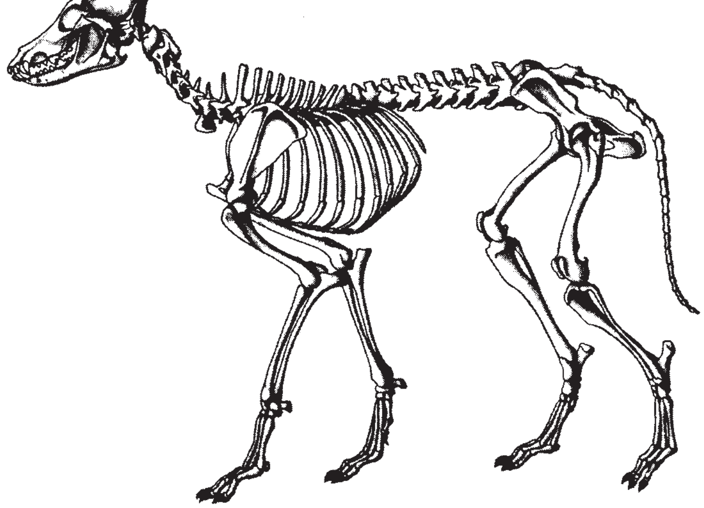

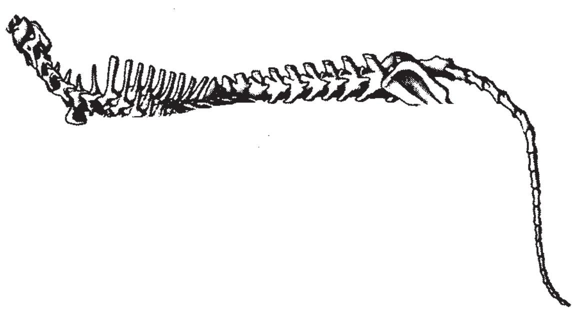

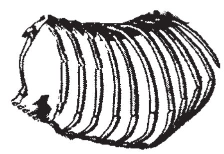

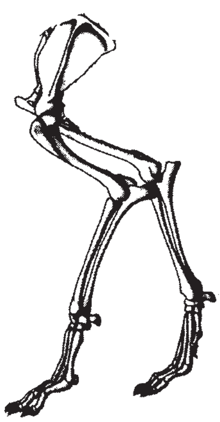

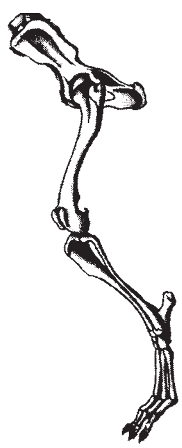

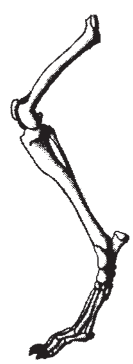

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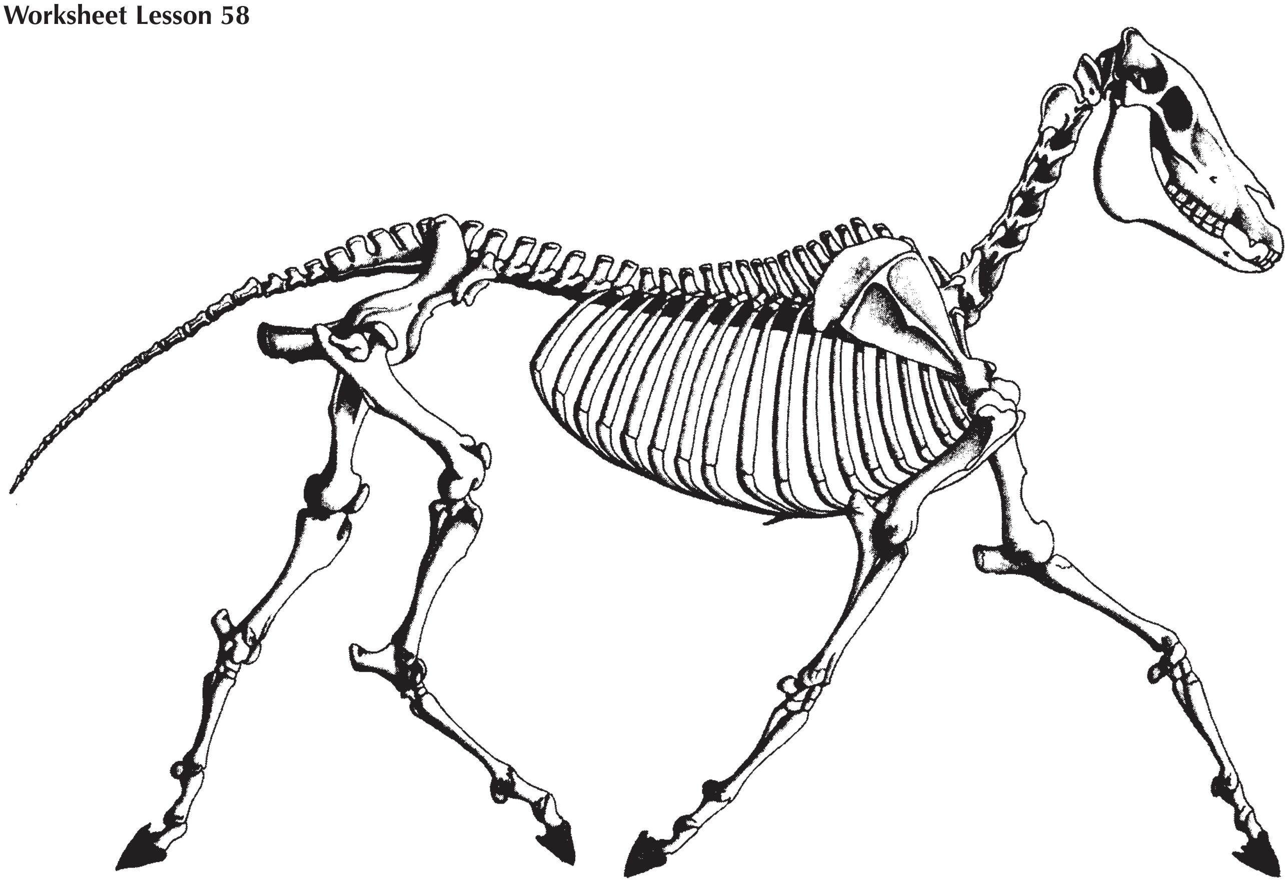

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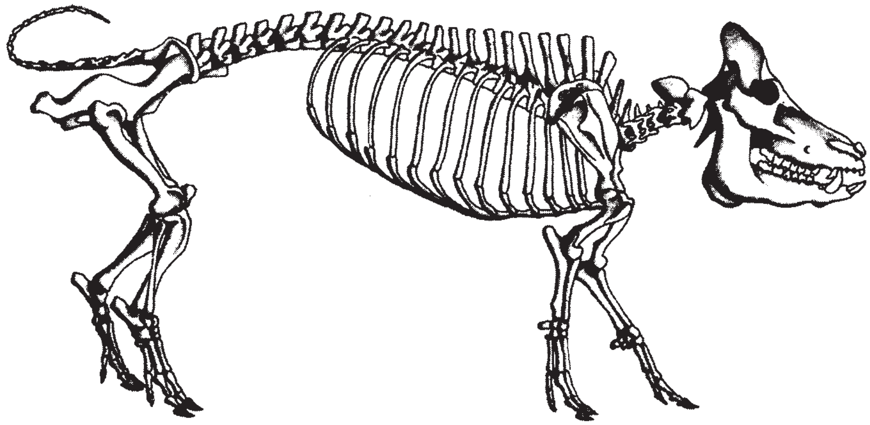

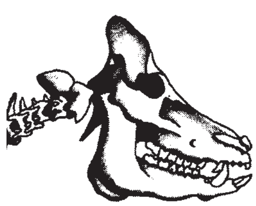

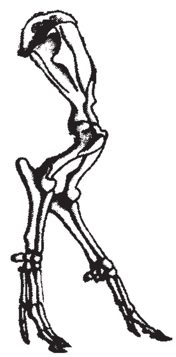

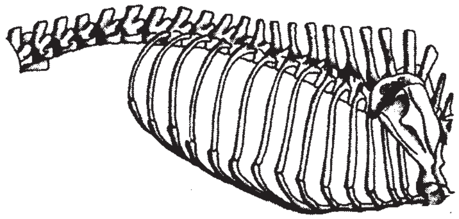

59. Fabricating Fossils

Equipment Needed

Small seashells, leaves, or other objects of choice, modeling clay, paper cups, plaster of Paris, water, petroleum jelly, plastic fork

Purpose

To learn about making inferences from imprints and casts of fossils
To emphasize that human knowledge is a valuable blessing but is also limited by everything that is human

Safety—Special Considerations

Be sure that students do not wash unused plaster down a sink drain. The plaster could harden in the plumbing.

Grade Level—Time Needed

Grades 1-6; Time: $1^1/_2$ class periods

Background

Ground water can gradually dissolve bones and shells trapped in sedimentary rock and remove them. A hollow impression of the object is left. This "imprint" shows the size and shape of the object that had been buried. Animal tracks and tunnels can be preserved in the same way as imprints. If the imprint is filled in by material deposited by ground water, a replica of the original object can be formed. It is called a "cast."

Procedure

Students will need a shell or any object with which they will attempt to make a "fossil" cast. Tell the students to put a thin coat of petroleum jelly on the object of which a fossil is to be made. Next, press the object into the clay. If the object is thin like a leaf, place a larger smooth object behind it and press. Remove the object and place the clay impression into a paper cup, image side up. In another cup make a thick and creamy mixture of plaster of Paris. Use half a cup of plaster and add water gradually, stirring each time. Pour the mixture over the clay, and let it set for a day. On the second day separate the hardened plaster from the clay.

Assignment

Identify the cast and the imprint. Explain how casts and imprints are formed.

Family Involvement

Make casts and imprints of the hands or feet of little brothers and sisters.

Christian Application

There are at least three areas of Christian application. First, fossils indicate that some forms of life are extinct (dinosaurs, trilobites). Good stewardship of the planet requires that we are concerned that our activities do not cause the extinction of any of God's creatures. God delighted in making all creatures; each having its place in the creation. Furthermore, the most obscure creature may become a valuable genetic resource for scientists. In 1996, Kathy Hodge, a graduate student, found the fruiting bodies (sexual stage) of a fungus called *Tolypocladium inflatum* living on the back of a particular dung beetle larva. The fungus in its asexual stage was previously used to produce cyclosporin. Cyclosporin is a drug that is used to prevent rejection of a transplanted organ. However, with the discovery of the fungus in the sexual stage, the door is open to culturing new strains of *T. inflatum* by exchanging genes with other fungi. This could improve the quantity and quality of cyclosporin that *T. inflatum* produces. According to Dr. Thomas Eisner, a Cornell biologist, Hodge's discovery shows what valuable creatures may still be found in our own backyards (Ward).

A second issue centers on the fact that we do not know how all the fossils found on the planet were formed. What were the circumstances of their death? Many of the fossils require that the creatures were suddenly killed and buried. Nevertheless, that the violence of the Genesis Flood, somehow, caused the formation of the fossils must remain speculation. Also that God might have just created the fossils as such without their ever having been alive, is another speculation. The Bible is rightly silent on this matter and many other interesting scientific questions, so we are not distracted or further puzzled. Recall Galileo's apt comment that the Scriptures show us how to go to Heaven, not how the heavens go. We must join Job and admit in humility that there are "things too wonderful" for us to completely understand (Job 42: 1-3).

We can look forward to asking God about such matters when we get to heaven. Presently, we do not know everything that God does and if we have an opinion on some of these things, we must keep it separate from Scripture. We must clearly show students what is Scriptural and what is human opinion—and not confound the two. Faith must not rest on our science, personalities, or a system of reasoning because science can change, people can be wrong, and any reasonable arguments can finally be out-reasoned by counter-arguments (cf. 1Co 2:1-4; 3:10-15).

Still another important understanding is that the fossil record does not compel us to believe in macroevolution. All scientists know that any organization of the fossils that have been found (in itself a very biased activity) shows gaps between the various organisms; there is a lack of gradual progress from one organism to another predicted by Darwinism. Our students also need to know that evolutionists do deal with this problem. Some scientists (neo-darwinists or ultra-darwinists) reply that clearly more fossils need to be found and then the gaps will be filled. However, Niles Eldredge and Steven Jay Gould maintain that evolution can sometimes move at a relatively faster rate. This would cause a much smaller chance of finding those transition fossils because the organism was not around as long as others. This is called the punctuated equilibrium theory. Evolutionism is basically assumed to be true while argument focuses on the particular mechanism (Wheeler). The fossil record really says nothing until inferences are made, and they can be wrong.

Extension

Learn what minerals dissolve easily in water to create casts and imprints.

References

Ward, Mark. "Cornell Students Find Rare Fungus." *Milwaukee Journal Sentinel.* September 30, 1996, p. 5A.

Wheeler, David L. "An Eclectic Biologist Argues that Humans Are Not Evolution's Most Important Result; Bacteria Are." *The Chronicle of Higher Education*. September, 6, 1996, A23-24.

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Nevertheless, that the violence of the Genesis Flood, somehow, caused the formation of the fossils must remain speculation.

60. Dinosaurs—Recognizing Animals by Their Skeletons

Equipment Needed

Drawings/pictures of intact skeletons or skeletal models of animals that are not extinct, pictures of the same animals (optional) (see Lesson 58)

Purpose

To give students experience in recognizing animals from their skeletons using observable clues

Grade Level—Time Needed

Grades 1-4; Time: one class period

Background

Skeletons give larger animals their shapes. Skeletons are made of individual bones that meet at joints. Teach the students that the form of the bone depends on the function it has. Form determines function, and function determines form. This is a major assumption made in anatomy and physiology.

Fossil skeletons are preserved bones or pieces of bone. They often have to be assembled like pieces of a puzzle to determine the size and shape of the animal that owned them. Bones may often be broken, missing, or mixed with other bones, making the task much more difficult. Scientists must sometimes compare with other similar skeletons and make some good guesses to complete a task. Mistakes happen. When discovered, good scientists will admit and correct the mistakes.

Procedure

Divide students into teams of two. Give each team a skeleton/picture of a skeleton. Tell them that it is a skeleton of a common animal that they can identify from the shape of the individual bones and from the entire skeleton. Have them agree on the animal to which the skeleton belongs. Have them notice the different parts of a skeleton: rib cage, skull, limbs, pelvic (hip) bones, breast (chest) bones. Then they should list the clues that helped them decide. After doing one skeleton, they can pass their specimen on to the next group and try another one until time is up. Allow time for them to share findings with the class.

Assignment

Give students outlines of a familiar animal. Have them use a marker to draw in what they think the inside skeleton may look like. Individual bones should be drawn to make up the skeleton. Students can start to learn the names of some of the bones.

Christian Application

God the Creator used a master plan for the forms of his creatures. The same general structure is used again and again. Skeletons are blessings that support, protect and allow God's creatures to move.

Extension

Compare breastbones, feet, skulls, etc. of different types of animals. How are they the same? How are they different? A book by R. McNeill Alexander has wonderful pictures of the bones from different animals.

References

Alexander, R. McNeill. *Bones: The Unity of Form and Function.* New York: Macmillan, 1994.

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61. Excavating Skeletal Remains: Chickensaurus

Equipment Needed

Partial or complete real skeleton (bones of a chicken or other small animal may be saved from a meal or also be obtained commercially from science supply company), a box to hold sand or soil about 30 cm x 30 cm and 8-10 cm deep, enough sand or soil to fill the box at least half full, small utensils to carefully remove bones, pencils, blank paper or science notebooks, pictures of possible animals and/or their skeletons (optional)

Purpose

To experience the discovery of a fossil deposit and its excavation.
To experience the challenge of identifying it and the strategies involved

Safety—Special Considerations

Sharp instruments should not be used. Small brushes and plasticware will work well to simulate actual tools of the paleontologist. Warn the students against spilling sand or soil out of the box. Enlist the students for clean up at the end of the activity.

Grade Level—Time Needed

Grades 4-8; Time: one class period

Background

See the *World Book* article, "Fossil." Often the head of a skeleton is found far from the rest of the bones because it rolls away.

Procedure

This activity can follow a study or discussion of how fossils are found. Review the understanding that a fossil is often partially broken, in disarray, and/or has bones combined with those of other animals. Tell students that they will be unearthing their own fossil. Do not tell them what the fossil is. Discuss how carelessness might destroy evidence on a real fossil dig (destroying fossils, not noting position of pieces). Assure students that they will have definite advantages over professionals in their arduous undertaking. They may be able to guess what kind of bones you might have buried (unless you have been fantastically creative). Their animal is a known species and not extinct. Furthermore, they may have pictures/diagrams that make it a multiple-choice event.

Students should work in small teams. Teams of two would be ideal if there are sufficient materials. Each team should be given a box in which you have created a fossil deposit along with the necessary equipment for excavation. Each team should have an excavator and a note taker. Tasks may be sub-divided for larger teams. They may take turns. Evidence should be recorded as it is unearthed by drawing pictures, showing positions, and making anecdotal notes.

Tell students to work carefully, moving a small amount of soil at a time and recording everything. Conjectures and conclusions should demonstrate the observable facts on which they are based. Have the students report their findings to the class.

Assignment

The unearthed material should be assembled (laid out) to show the completed find. Notes should be written up as a report showing evidence and conclusions.

Christian Application

Since fossil formation requires rapid burial and water, some Christians have felt that many of the fossil were formed by the Flood waters. The large number of fossils, the condition and position of many fossils—caught in the act of swallowing prey, and various positions suggests a sudden, violent situation. While this is interesting, we cannot be sure of this and such an inference should not be used in an attempt to "prove" or support the Bible (an unnecessary and dangerous task). The person who has rejected Scripture will have different reasonable answers for what is discovered in the fossil record.

Extension

Place skeletal parts of more than one organism in the box. Study pictures of dinosaur dig sites. Study differences in the skeletons of mammals, birds, reptiles.

Glue the skeleton back together for a three-dimensional display.

Students will enjoy reading the series of articles and illustrations found in the June 5, 1995 issue of *Newsweek*.

References

Adler, Jerry with Adam Rogers. "The Great Boneyard of the Gobi." *Newsweek,* June 5, 1995, p.56.
Begley, Sharon. "Lifting the Veil." *Newsweek,* June, 5, 1995, 50-57.
Begley, Sharon. "New digs for Old Bones." *Newsweek,* June, 5, 1995, 58-60.
Horner, John R. *Digging Dinosaurs.* New York: Workman, 1988.
Will, Richard and Marjory Read. *Dinosaur Digs: Places Where You Can Discover Prehistoric Creatures.* 1992. (especially ch.4; good pictures of excavation sites and specimens)
—- "Fossils." *World Book Encyclopedia.* Chicago: Field Enterprises Educational Corp., 1977.

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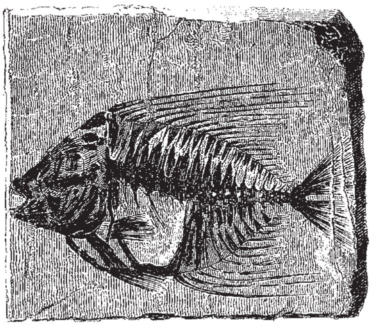

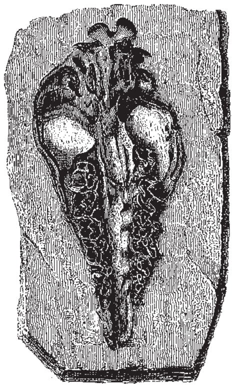

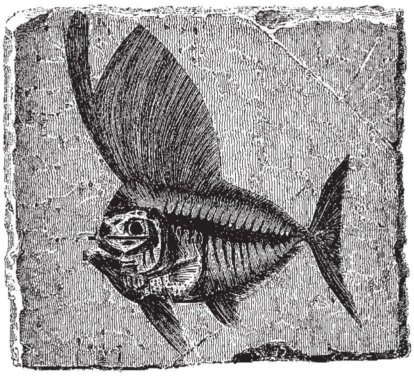

62. Dinosaurs—Dino-Puzzle

Equipment Needed

Several primary-level jigsaw puzzles picked up at rummage sales or cut up magazine photographs

Purpose

To appreciate the challenge to the paleontologist who has to assemble a dinosaur skeleton with parts missing, broken, and often mixed with others

Grade Level—Time Needed

Grades 3-8; Time: One class period with discussion

Procedure

Using several puzzles, mix pieces together in random piles. Provide one pile for each group. Have each group work on its pile. It is best if the color of the back side of a piece does not help in sorting the puzzle pieces.

Fossils are often incomplete, have broken parts, and are mixed up with the parts of other fossils. No picture can help unless the worker recognizes certain parts as coming from an already known dinosaur.

Assignment

Report your conclusions about the puzzle to the class as if you are reporting the results of finding fossils to a scientific meeting.

Christian Application

The difficulties involved for paleontologists may cause them to draw wrong conclusions. God, who knows all things, does not reveal some of the mysteries of his creation. Some of what we are told about dinosaurs may be largely conjecture (guess work). Conjecture is okay if we realize what we are doing.

Extension

Find pictures of excavation sites and fossils. Discuss the challenges and problems involved.

Students may enjoy "Fossil Hunter" a MECC Apple II program. The program encourages the application of science process skills in the identification of common fossil organisms.

Students may enjoy reading or hearing about why the fossilized tail of an Ichthyosaur is always bent downward in the same place (Gould). (An upward caudal fin was hypothesized to exist at that location.)

References

Gould, Steven Jay. "Bent Out of Shape." *Eight Little Piggies*. New York: W>W> Norton, 1993, p. 79-94.

Thenius, Erich. *Fossils and the Life of the Past*. London: The English Universities Press, 1973.

—— "Fossil Hunter." St. Paul, Minnesota: Minnesota Educational Computing Corp., 1990.

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63. Chemistry in the Eye

Equipment Needed

Colored markers, outline of the flag (a drawing of the U.S. flag is provided with this lab), a brightly lit area or a lamp to increase the intensity of the colors

Purpose

To demonstrate that our vision depends on chemical reactions

Safety—Special Considerations

Warn the students not to touch a hot lamp if it is used to increase the intensity of the colors. Be sure that the lamp is stable. Coloring with boldly colored markers works best. To see a particular part of the flag better try looking off to the side of the portion you want to see, not directly at it.

Grade Level—Time Needed

Grades 7-12; Time: 15 minutes

Background

This is a lab for anyone who has ever experienced having a complementary image of a Lutheran pastor drift off on the chancel wall during a sermon. This is called, "afterimage." It has to do with how our eyes work. When light enters the receptor cells of our retina, a chemical reaction occurs. There are two general types of receptors named for their shape: rods and cones. Rods are more sensitive than the cones and are responsible for our being able to see in dim light. The cones are of three types, red, green and blue. We see different colors depending on which receptors are activated. Equal activation of all three at once produces white.

If one of the three receptor types, like the red cones, is stimulated for a time, its response will adapt and be less intense, perhaps because changes in chemical concentrations. If one looks at a red object for a while and then at a white object, the white light will stimulate all three types of cones. In this case, however, the red cones which have already been working will not be as sensitive as the green and blue. One will see green, and blue instead of all three which equal white. The generalization is that if one stares at any color and then at white, one will see the complement of that color. The complement of red is cyan (green-blue). Blue becomes yellow. Some scientists even call yellow, "minus blue." If we take out green, you will get magenta (Check *World Book* for photos of this).

Vision is an elaborate process that uses about half of the brain's cortex. James Elkins (1996) maintains that we are not merely looking; we are actively seeking. What we see depends on surroundings and what we have been looking at before.

Procedure

Have the students look up the words, "complement" and "compliment" and record the meanings. Duplicate the U.S. flag on the next page. Have the students color the flag. However, from the top down, the stripes should be colored green, black, green...with green at the bottom. The box with the stars (the field) should be colored yellow and the stars, black. After the coloring is complete, stare directly at the flag for about 30 seconds under well-lit conditions. Count one-thousand one; one-thousand two...to thirty for the 30 seconds. Then quickly shift your eyes to the white part of the paper below the picture. What do you see? (If you see the red, white and blue flag for a few seconds you have done well. Some students may have problems staring at an object for a long time.)

Assignment

Have students place individual colors on a paper. They should stare at each color and then record in chart form, what they expected to see when they look at white and what they actually see when they do it.

Christian Application

God made our wonderful eyes. If he made our eyes so that we can see, it would be a mistake to think that he does not also see us and that He does not pay attention to what we do (cf. Ps 94: 7-9).

Extension

What happens if you stare at a colored image at a given distance and change the distance of the white paper? You might substitute a blank wall in the room. *Does the image stay the same size?* (No, it varies directly with the second distance. A larger second distance will make a larger afterimage.) Try a smaller distance.

References

Elkins, James. *The Object Stares Back: On the Nature of Seeing*. New York: Simon and Schuster, 1996.
Evans, Ralph M. "Color." *The World Book Encyclopedia.* (Vol. C) Chicago: Field Enterprises, 1976, 659a-666. This is a very good article which indicates some of the historical disagreement among scientists about the nature of color vision.
Sacks, Oliver. *The Island of the Colorblind.* New York: Knopf, 1997.
Tov'ee, Martin J. *An Introduction to the Visual System.* Cambridge: Cambridge University Press, 1996.

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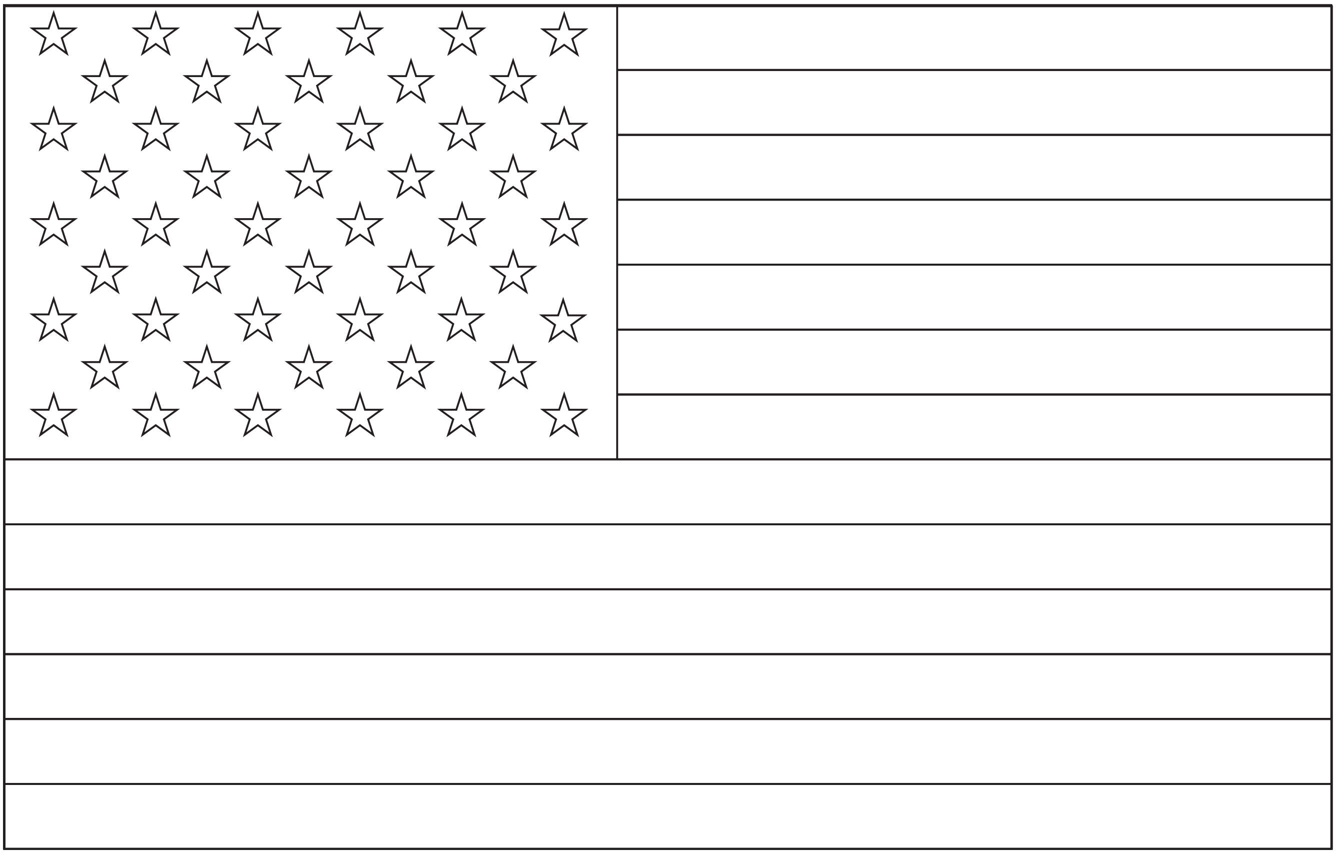

64. Walking Naturally

Equipment Needed

A place that is remote, a bag for collecting litter (preferably one for recyclable and one for non-recyclables)

Purpose

To investigate the effects that humans can have on the environment

Safety—Special Considerations

The instructor should follow school policy on field trips: informing parents and administrators. If private property is involved the instructor should have permission from the owner and should anticipate any hazards on the property. The instructor should inquire about poison ivy, ticks, or other possible problems. Student should wash their hands after they return from the trip.

Grade Level—Time Needed

Primary grades; Time: time for field trip plus one class period

Background

All organisms modify their environments. Humans need to take care in all they do. We need to consider all the costs of our actions. Human litter is found all over the Earth and in space. Litter should be recycled. Some litter is dangerous to animals. Birds and other animals can become entangled in fishing lines and plastic from six-packs. Litter in space may hit spacecraft and be dangerous to astronauts, and larger objects can be dangerous for humans on Earth when they drop out of orbit.

Christian teachers need to be aware that many in science blame Christianity for careless attitudes toward nature. In 1967 Lynn White Jr. wrote his (now considered a classic) article charging Christian attitudes with blame for our current ecological problems. White said that Christianity is man-centered and that Christians consider themselves to be superior to nature and are even contemptuous of it. Christianity fought for centuries to overcome the early Gnostic beliefs that treated nature and physical things as evil. Christianity is not to blame for environmental problems; people are. Of course, Christians often fail, as part of the Old Adam, sometimes on purpose, sometimes out of lack of understanding. We are not perfect. Growth in faith will encourage us to act better toward the creation and renew our God-given role as caretakers.

Procedure

Make arrangements for a class field trip to a remote area. The area should be a place where there is little trace of human life.

In the classroom before the trip develop guidelines for the students. Tell the students to investigate with care. Discuss how this can be done. Ask them if they should kill any animals or plants. If they turn a rock over, they should put it back the way it was. The rock may be someone's home. Have students explore the area and compare it to other places with which they are familiar. Assign students to groups in charge of answering each of the questions below. (Have the students agree to share and report any important findings to the captain of the particular group that would be interested in that data. Also have all students place any litter into collection bags.)

- *How is this area environmentally different?* (less noise pollution, less litter, more diversity in plant and animal life, a restful, carefree environment...)
- *Are there any signs of human activity? Make a list of any litter found.* (Usually there will be litter even in the most remote places.) *Compare the amount of litter found here to that*

found along the highway. Where did the litter come from? (careless people, wind)

- *How many different animals live here? Make a list of the animals. Draw pictures of those that cannot be named.*
- *How many different plants live here? Draw pictures of those that cannot be named.*

After returning have the groups prepare displays of their data (charts, pictures, actual litter) on the bulletin board.

Discuss the trip. Talk about the world as it was given to Adam and Eve. *What was the Garden of Eden like? What job did God give to humans?* (caretakers)

How has sin affected the whole creation (Ro 1:19-20)?

Family Involvement

Students should share the results of the field trip with their family. The family could be encouraged by a note from school to discover a new way to reduce waste at home.

Christian Application

God has made us the caretakers of nature. That is a wonderful job. Nature impresses us with its beauty and complexity and thereby tells us that there is a wise, all-knowing God. "For since the creation of the world God's invisible qualities—his eternal power and divine nature—have been clearly seen, being understood from what has been made, so that men are without excuse" (Ro 1:19-20). At the same time we see the effects of our sinfulness on the creation: "For the creation was subjected to frustration, not by its own choice...we know that the whole creation has been groaning as in the pains of childbirth right up to the present time" (Ro 8:19-22). Still, as the caretakers of the planet we need to know as much as we can about nature in order to be wiser caretakers. This is a strong reason to continue to study science.

Extension

Students could develop plans to reduce waste at school or home.

References

White Jr., Lynn. "The Historical Roots of Our Ecologic Crisis." *Science* 155, 1203-1207 (March 10 1967).

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> *"Christianity is not to blame for environmental problems; people are."*

65. Ziploc Garden: Exploring Seed Germination and Plant Growth

Equipment Needed

Per pupil: plastic sandwich bag (Ziploc™ are best), paper towel, one teaspoon of birdseed (or other seeds), ruler and pencil, staplers

Purpose

To discover the conditions under which seeds germinate best
To see the difference between the roots and stems of plants
To observe root hairs and plant tropisms

Safety—Special Considerations

Small children may need supervision when using the stapler. Mold may develop in the bags if old birdseed is used, so fresh seed is suggested.

Grade Level—Time Needed

All grades (with minor modifications); Time: one class period for initial setup

Background

This activity is a simple but effective way to study seed-germination. The materials are affordable and easily obtained. The activity lends itself to being partly a homework assignment. It may be done with young children, or may have more variables included for older students.

A tropism is movement in response to a stimulus. The response can be toward the stimulus (positive) or away from it (negative).

Procedure

Have students fold a paper towel to fit just inside the plastic bag. (Note: For older students, this could become a measurement activity. Give them a set of metric dimensions for the towel and have them measure and fold the towel.) When the towel is fitted for the bag, use a ruler and pencil to draw a horizontal line on the towel that is about five cm from the bottom. The bottom is the end opposite the opening of the bag.

With the towel inside the bag, staple a line of staples along the five cm pencil line on the paper towel. The staple line is made horizontally across the bag. Staple through the bag and the towel and be certain that the staples are close together so that the seeds cannot fall to the bottom of the bag.

Now add the seeds. Be sure to put no more than one teaspoon in the bag. At this point, students can fasten the top of the bag with tape or staples if Ziplocs™ are not used. At home the students may add the water, just enough to wet the paper towel. The bags may be hung on the wall or on a bulletin board after they stop dripping.

Students may experiment with variables, for example, different amounts of light and darkness, temperature (put some in the refrigerator), less or more water, different kinds of seeds. After the seedlings have grown for about a week, give students magnifiers to observe the root hairs. Each root hair is a single cell which absorbs water and minerals from the soil into the plants

After the seedlings have grown for a week or more, tip the bag to one side and leave it that way for a day or more to see how plants respond by changing direction. This can help to illustrate phototropism (response to light) and geotropism (response to gravity). Have the students learn these terms. Are the responses positive (toward) or negative (away)? A student can record that the plants show positive phototropism.

Assignment

Students should be required to keep a daily log on their bag. Challenge students to come up with their own criteria for types of data to be recorded. They should also come up with the science skills that they will be using to collect the data (e.g., measurement, observation, variable changes). Introduce words that they will need to use in keeping their log (e.g., germinate, seed coat, chlorophyll [green reflecting pigment that captures light energy], cotyledon [one or two structures that look like leaves but actually contain food for the plants], primary [main] root, secondary [branch] roots, root hairs, stem).

Family Involvement

If the students bring the bags home, family involvement will be encouraged because the growth of plants is easily visible and changes daily. They will love having something different to place on the refrigerator door. A family garden is the next step.

Christian Application

God has given us many types of plants to enjoy and use. A seemingly lifeless seed is changed into something beautiful. Science, of course, tells us that the seed is not really dead. Yet it can be a nice object lesson to remind us of our own resurrection, which will be more marvelous. Here science would conclude that we shall be dead by any human measurements. Yet, God will make us alive again, and we will be with our Lord.

Extension

Seeds that produce tap roots, such as a radish, produce good samples of root hairs. Root hairs usually last only a few days as the root continues to grow. Many root hairs have a large total surface area to absorb water and minerals through diffusion.

References

Raven, Peter H. and George B. Johnson. *Understanding Biology*. Dubuque IA: Wm C. Brown, 1995.

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Ziploc is a registered trademark of the Dow Chemical Company.

"Science, of course, tells us that the seed is not really dead. Yet, it can be a nice object lesson to remind us of our own resurrection, which will be more marvelous."

66. Analyzing the Content of Soil

Equipment Needed

Per group of four students: two egg cartons, four tweezers, two magnifying lenses, two cups of topsoil, newspaper, marker, large plastic bag or tub, white paper

Purpose

To discover the composition of soil
To compile a recipe for making soil

Safety—Special Considerations

Students should wash their hands when they are finished. A hardware store or a plant nursery will be able to provide the soil needed for this lab if you don't have access to dig your own. Newspaper spread over the desks is a must since it will aid in clean up. The tops of the egg cartons should be removed prior to starting.

Grade Level—Time Needed

Grades K-8; Time: one 20-30 minute class period

Background

This is an enjoyable lab because the students discover the complexities of soil, something they walk over without much thought. Students will do better if they have previous experience in observation and sorting skills.

Soil is a mixture of minerals and humus. The minerals come from the weathering and erosion of rock into small particles. The humus is organic material which comes from plants and animals. Humus supplies plants with nitrogen, phosphorus, potassium, and other essential elements. Humus retains water well and keeps soil from drying out rapidly. The dark color of humus causes the soil to absorb sunlight which causes the soil to become warm. Worms are very important in soil; they loosen the soil by tunneling through it and add air. They also break down organic matter, pass it through their bodies, and add it to the soil. Worms are soil-builders. When you dig in the soil you may at first encounter a maze of roots and fungal threads woven between the soil particles. On closer inspection you may see an assortment of little animals as well. It is estimated that 95% of all insect species spend part of their lives in the soil. Many other small creatures make their homes there too. Soil is also the final resting place for plants. Soil contains the remnants of plant parts that fall to the ground each season and are broken apart by organisms called decomposers.

Procedure

Have students predict what they will find in the soil and record their guesses on their lab sheets or on the board (for younger students). Divide the students into groups of four and distribute magnifying lenses. Give each group two cups of topsoil and instruct them to pour it onto a white sheet of paper. Inform the students that the team goal is to find things in the soil and to sort the individual parts into the compartments in the egg cartons. If they find items that have already been discovered, place them in a compartment with the same objects.

After 10-15 minutes, ask each team to show each other what they found and list the items on their lab sheets (or the board for younger students).

Assignment

Using estimation skills, have students construct a bar or pie graph of the materials found in their soil. Using the graph as a basis for amounts, have students construct "recipe cards" for soil.

Family Involvement

Students can duplicate this lab at home and share different soil types with the class. Students can exchange recipes and bring the "ingredients" from home. Student may want to start a compost heap at home.

Christian Application

God is his wisdom has created soil in which seemingly lifeless matter helps to provide life for plants and shelter for insects. He also made us out of soil.

Extension

Since there is no life on the moon, there is no soil. Moon dirt is called regolith, a term that describes pulverized rock that contains no organic matter.

It may be possible to set up a compost heap on the school grounds and make soil.

References

Campbell, Stu. *Let It Rot. The Grandmother's Guide to Composting.* Pownal, VT: Storey Publications, 1990.

Reay,Georgia J. *Yard Waste Management Guidance.* Madison,WI: Wisconsin Department of Natural Resources, 1994.

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Polymers

An overview of a chemistry unit for middle grades through high school

Introduction

Ever since your students were "civilized" with their first disposable diaper, they have been surrounded by polymers (PAHL-ee-merz). Polymers have become a large part of the modern environment. These large molecules are made by smaller units which are linked together in chains. The repeating smaller units are identical or at least similar.

Students needs to know about polymers. This unit will even give them the chance to understand polymers' properties, learn about their uses, and make a few polymers. Activities also can be as simple as making a most exquisite slime or making a 30-inch continuous thread.

General Background for Understanding Polymers

Some History The earliest known use of polymers dates back to the ancient Egyptians who used shellac. Shellac is a secretion of resin from the female lac insect. It dries in flakes (the shell form). Shellac varnish is a solution of shellac in denatured alcohol. Shellac continues to be used for everything from indoor wood finishing to giving jelly beans a shiny coating.

All plastics are polymers. The first plastic was developed by Alexander Parks in 1868. His invention, cellulose nitrate, has been made into both an explosive called gun cotton and into the film celluloid, which was later used by the motion picture industry.

The first completely synthetic plastic came about when Leo Bakeland developed a product called Bakelite™. You may have handled Bakelite if you can remember the old black phones whose receivers seemed to weigh something just short of a metric ton.

Today we use many different polymers. Over 90% of all manufactured goods, including products, containers, coverings, and wrappers are made either in part or completely of polymers. Think of the uses we have for the different plastics. Most plastics today are products of oil, natural gas, or coal. In the United States alone more than 15 billion pounds of polyethylene are produced every year, which makes it the most common plastic.

Nature is also full of polymers including proteins, amino acids and, the longest of polymers, DNA. These molecules are found in living things.

The Chemistry A polymer is a molecule that resembles a long chain. Each link in the chain is called a monomer. Polyethylene, for instance, is made of thousands of monomers; each one is an ethylene. Chemically speaking, ethylene looks like this:

The molecule goes on and on. Nobody bothers being specific about the "n" which stands for the number of monomers per molecule since it varies with the length of the material and is almost uncountable.

Because a polymer is such a long chain, it is very flexible, hence the name plastic. It is often in a liquid form. It can be stiffened into a gel or solid by use of a cross linker. Cross linkers are chemicals whose smaller molecules link the long chains of a polymer from side

$$CH_2{=}CH_2$$

and polyethylene looks like this

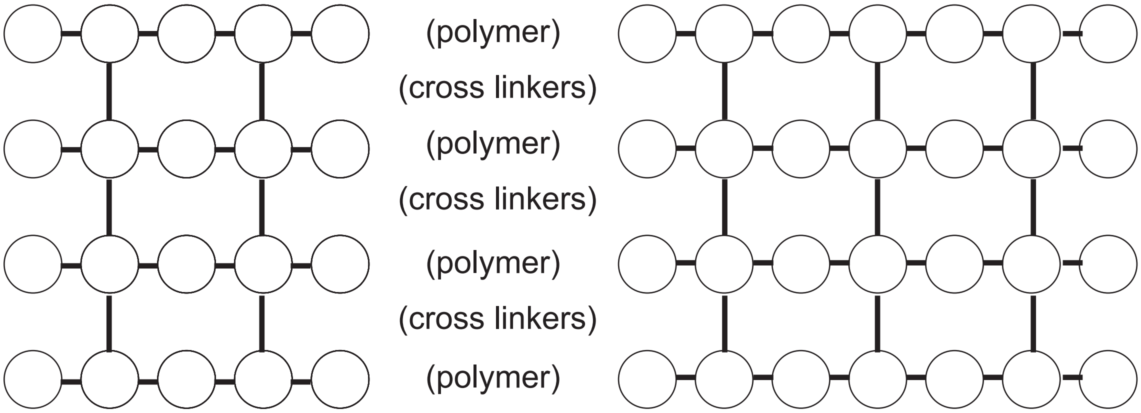
$$...{-}CH_2{-}\ CH_2{-}CH_2{-}CH_2{-}CH_2{-}\ CH_2{-}CH_2{-}\ CH_2{-}...$$

or simply

$$(-CH_2-CH_2-)_n$$

to side. A model of cross linked polymers may look like this:

Try a unit on polymers with your students. The chemistry can be kept very simple. Your students are probably ready to understand polymers if they have a basic knowledge of atoms, molecules and bonds.



(Model of polymer made more "stiff" by cross linkers)

Unit Overview

I. What is it?
   1. Needle through a balloon
   2. Making casein plastic
   3. Making Styrofoam disappear

II. What will it do?
   4. Poly-Kaleidoscope
   5. Making casein glue
   6. Making a continuous thread from food wrap
   7. Slime
   8. Making erasers
   9. Super balls

III. How is it used?
   10. Find poly
   11. Making a polyvinyl interface

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1. Needle Through a Balloon

Equipment Needed

A bamboo skewer, upholstery needle or sharpened knitting needle; a capful of lubricant such as cooking oil, petroleum jelly, or dish washing liquid; a latex balloon (most party balloons are latex)

Purpose

To make students curious about polymers

Safety—Special Considerations

The teacher should rehearse this demonstration. Because of the use of a needle this activity should be performed as a teacher demonstration. A demonstrator could stab a hand if the procedure is not done slowly. Students should be told of this hazard and told not to try it by themselves. Young children should not inflate balloons. A young child may inhale a balloon, lodging it in the airway. This can cause death from a lack of oxygen.

Grade Level—Time Needed

Grades 2-12; Time: 10-15 minutes

Background

Balloons are made by dipping an internal mold into a vat of liquid latex. The thin layer left on the mold is made of polymer chains of latex. When the balloon is inflated, the polymers at the sides are stretched while the ends of the balloon remain thicker. Often this can be seen by observing how light penetrates the balloon. When a needle is inserted, it gently pushes the chains to either side. When the balloon was given a quick jab on the side, the polymer chain were stretched tight enough that they couldn't slide further apart without tearing. Once a tear starts, it continues rapidly, releasing air and thereby creating the pop.

Students need to realize that when chemical reactions occur, the new materials formed as a result will have different properties from the original chemicals.

Procedure

1. Slightly under-inflate a balloon. Close the balloon by knotting the open end.
2. Dip the end of a needle into lubricant and spread over length of needle with finger. Put a little lubricant on the knotted end of the balloon and the area opposite the knot.
3. Using a twisting motion, insert needle into the end opposite of the knot.
4. Continue pushing and twisting the needle until it emerges from the opposite end near the knot.
5. Using a different needle, pop the balloon by a quick jab on the side showing it was a real balloon.
6. Explain that balloons are made out of long cross-linked molecules called polymers. Poly = many. The molecules form a structure analogous to a net. If the balloon is not stretched too tight, the net with remain together, and the balloon will not break.

Extension

Any large plastic bag is also made of polymers. Try filling a zipper topped bag with water and poke a pencil through the bag. If done carefully the polymers will seal around the pencil and the water in the bag will not leak out.

Christian Application

There are wonders in the creation that are beyond our senses. For by him all things were created: things in heaven and on earth, visible and invisible... (Col 1:16). What a wonderful creation that God allowed for chemistry that can make new compounds with new properties.

References

Sarquis, A.M. *Fun with Chemistry*. Madison: Institute of Chemical Education, University of Wisconsin, 1991.

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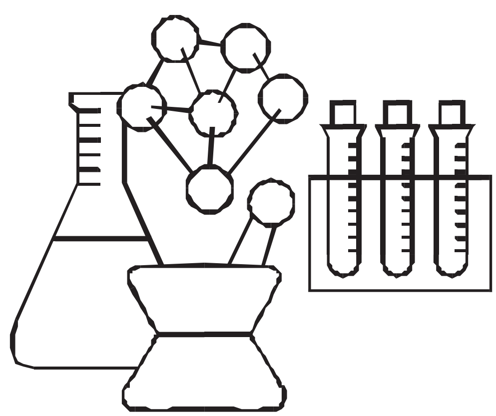
"There are wonders in the creation that are beyond our senses."



2. Making Casein Plastic

Equipment Needed

An open sauce pan, a heat source (hot plate, Bunsen burner, etc.), one cup of skim milk, two tablespoons of white vinegar, goggles for those using and near the burner, sink or large bucket of water

Purpose

To allow students to easily produce a natural polymer and to handle the polymer and discover some of the properties of a polymer

Safety—Special Considerations

Use caution and wear goggles while working with the hot plate and boiling milk. With younger students the teacher may wish to do the hot plate portion of the activity. Make sure the milk has sufficiently cooled before removing the casein from the pan. Teach the students not to pick up an object if they feel heat when they approach the object with the back of their hand.

Grade Level—Time Needed

Intermediate through high school; Time: 30-45 minutes

Background

Caseinogen (kay-see-EHN-oh-jen) is protein in the milk which becomes the monomer in the chemical reaction to form the polymer casein. The vinegar provided hydrocarbon molecules so that the polymer chain could be formed. When the casein was first removed, the chains were still relatively long and consequently flexible. As the casein dried it was actually thermosetting which makes the chains rigid. Thermoset plastics may not be reheated and reshaped.

Procedure

1. Place one cup of skim milk in the pan and bring it to near boiling.
2. Stir in 2 tablespoons of vinegar.
3. Continue stirring until lumps begin forming (about three minutes). The lumps are the polymer called casein (KAY-seen or KAY-see-ehn).
4. Remove from heat but continue stirring as liquid cools.
5. When the pan is cool enough that it can be handled, remove the casein lumps that have formed and wash them under tap or rinse in container of water.
6. Have students shape the casein into objects and allow several days for their casein sculptures to harden.

Assignment

Make a list of everyday things that might be polymers made by humans. Ask the student to try to find out the name of the suspected polymer and find information on it in *World Book*. (Expect a list of plastics. This assignment is more broad than lesson 10, "Find Poly.")

Christian Application

It might be interesting for the students to note that polymers are not just the product of test tubes in laboratories but also a part of creation. Just as they were able to form the protein in the milk into a polymer, God set up the cells of our body to produce polymers out of protein such as amino acids and DNA. The body also polymerizes sugars into starch for energy storage in the liver and on the muscles.

Extension

Casein today is used for making such things as glue and shirt buttons. Some students may wish to sculpt their casein lumps into buttons. A water proof glue can be made using your casein. (See lesson 5 "Making Casein Glue.")

References

"The Shaping of Things to Come" pamphlet and activity set available from The Society of the Plastics Industry, Special Communications, 1275 K Street, NW, Suite 400, Washington, DC 20005.

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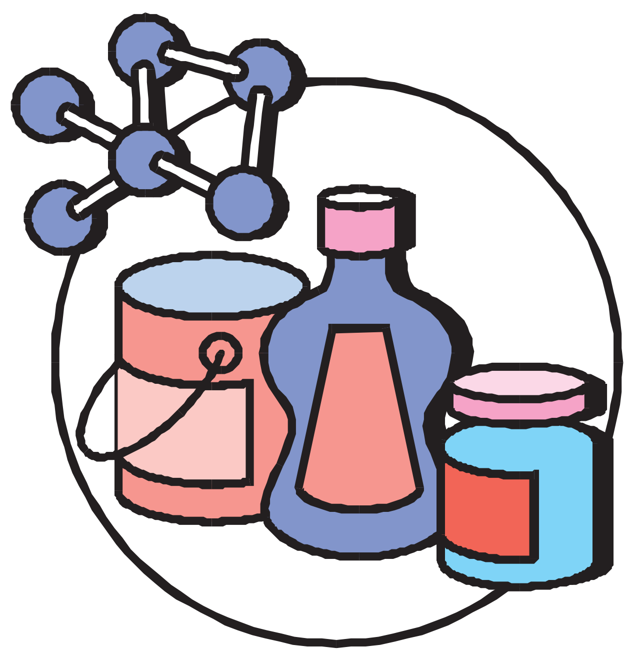

3. Making Styrofoam Disappear

Equipment Needed

Several Styrofoam cups (other Styrofoam products may be substituted such as packing peanuts); clear styrene cup such as a clear, hard plastic disposable cup (optional); acetone (available at hardware and paint stores or school chemical supply houses); clear glass beaker or dish forceps, tongs or tweezers; aluminum foil or plastic wrap; sink or bucket filled with water

Purpose

To show that gases may be trapped between layers of a polymer to give it new properties

Safety—Special Considerations

Acetone is a very volatile (evaporates quickly) substance. Do this activity near an open window or where there will be enough ventilation to carry the fumes away. Goggles should be worn by those near the acetone. It is also very flammable and toxic—exercise appropriate precautions. The residue left behind in the acetone shouldn't be handled with bare hands. Be sure that the acetone is closed tightly and is stored in a locked cabinet.

Grade Level—Time Needed

Middle grades through high school; Time: 15 minutes

Background

Styrofoam cups are made of a styrene that expands as it hardens by trapping escaping gasses between its polymer strands. When it comes in contact with acetone the strands "relax" allowing the gases to escape from the styrene. A small amount of acetone alters a large amount of Styrofoam since the amount of styrene is relatively small compared to its volume.

A major fast food company (McDonald's) stopped using Styrofoam packages for their larger hamburgers because people pointed out that the usual type is not biodegradable and is not easy to recycle. The company now uses materials that are biodegradable. This shows that people can affect the practices of large businesses.

Procedure

1. Show the students a Styrofoam cup and a clear styrene (polystyrene) cup and ask them to list the differences between the materials that make up the cups. (Since both are made from styrene the only major difference is the gas trapped in the foam cup. Save this information for the discussion after the activity to see if any students can deduce this from the demonstration.)
2. Pour acetone to depth of one cm in the glass container.
3. Make Styrofoam disappear by adding it to acetone. Add drama by adding several more cups to this ravenous chemical.
4. Remove any solid residue with forceps, rinse and allow to dry on foil.
5. When the styrene finishes drying on the foil, it should harden and can be compared to the original cups. However, the residue shouldn't be handled with bare hands.
6. Ask the students if they know what it is now.
7. Discuss the fact that both are made from polystyrene. The difference in properties is due to the trapped gases in the Styrofoam.

Extension

Some Styrofoams (newer packing “peanuts”) are made biodegradable by using a mixture of styrene and cellulose from corn. These foams can be broken down by adding water. Though it is less dramatic to watch these foams degrade, you may wish to show this and discuss how these foams may be beneficial to waste disposal. Of course, one cannot make a cup from this kind of Styrofoam. Another problem with biodegradable foams is that most of these may end up in a landfill before they get wet and degrade. This counteracts their purpose since a well maintained landfill is packed and layered to keep water from seeping into or out of its contents. If these foams degrade in the landfill, they are likely to leave pathways for seepage.

References

Sarquis, Mickey. *Partners for Terrific Science Teacher Resource Module: Plastics and Polymers*. Oxford, Ohio: Miami University, n.d.

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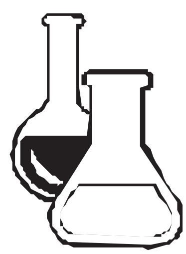

4. Poly-Kaleidoscope

Equipment Needed

Cellophane tape (the cheaper the better, Scotch Brand and invisible tapes do not work); cardboard or bathroom tissue tubes; polarized film sheet cut in 2S x 2S squares (available from Edmund Scientific, 101 E Gloucester Pike, Barrington, NJ 08007)

Purpose

To demonstrate the light properties of some polymers and see how light passing through some polymers can give us clues about the orientation of their strands

Safety—Special Considerations

Be sure to try your tape out ahead of time since not all tapes have these special properties

Grade Level—Time Needed

High school; Time: 20 minutes

Background

Polarized light is one of the most useful tools for studying the characteristics of materials that allow light to pass through. Polarized film is a polymer with its molecular strands running in one direction (like a picket fence). Therefore, the polarized film allows only light waves that are vibrating in one direction to pass through; all other waves are blocked by the molecules. The light that passes through polarized film is called polarized light. It is interesting to note that the light we see from a natural rainbow is polarized. Most of the light that is reflected from non-metallic surfaces is also polarized.

When the polarized light hits the tape, because the polymer strands are likely in a different direction than the polarizer, each color (wavelength) ends up being rotated so that it is vibrating in its own direction. If the alignment of the tape's molecules are in the same direction as the polarized light is vibrated, white light will be transmitted. If other directions are chosen, colors will occur. To see the individual colors, a second polarized film called an analyzer is needed. The result is spectacular, especially if the analyzer is rotated. The effect is evidence that our ideas about polymers being long molecules are correct. Hewitt gives a more complete explanation of this demonstration involving vectors in his popular physics text.

Procedure

1. Cover the end of a cardboard tube with several crisscrossing layers of cellophane tape.
2. Place a square of polarized film across the end covered with tape and view a light source or place on an overhead projector to view together as a class. This polarized film closest to the light source is called the polarizer because it polarizes the light before it hits the cellophane tape.
3. After the light goes through the polarizer and then through the cellophane tape, place a second polarized film. Rotate this second film, called the analyzer to show a kaleidoscope-like color changes.

Summary of the setup:

1) light source—->polarizer—->cellophane tape—->analyzer—->eye

Christian Application

The Lord placed the rainbow in the sky as a sign of his covenant with Noah and all mankind. Anytime we see the display of a spectrum we can be reminded of the Lord's promise.

Extension

Other forms of clear polymer will also refract polarized light. Use a hot plate to melt a clear overhead sheet (acetate) until you can stretch it. (Do not use an open flame; the acetate could ignite. The stretching orients the strands and should produce a kaleidoscope effect when viewed in the position that the cellophane tape had in the first demonstration. The clear windows on envelopes and the rings from six-packs may also give you the same effects.

References

Hewitt, Paul G. *Conceptual Physics*. Glenview, Illinois: Scott, Foresman, 1989, pp.532-3.

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“Anytime we see the display of a spectrum we can be reminded of the Lord's promise.”

5. Making Casein Glue

Equipment Needed

Fresh casein from previous activity (see “Making Casein Plastic”; borax powder (available as a laundry product from most grocery stores); water; disposable cups and sticks for mixing

Purpose

To show an additional property of polymers by making an adhesive

Safety—Special Considerations

Goggles and suitable precautions should be taken when working with chemicals. This activity will produce a permanent glue— be careful to clean the glue off any non-disposable utensils before the glue sets.

Grade Level—Time Needed

Intermediate through high school; Time: 30-40 minutes if you are working with previously made casein

Background

The way an adhesive works could be understood by comparing it to chewing gum, which is also a polymer. For an adhesive to stick, it must first wet or completely cover the surface. While still liquid, the polymers of the adhesive flow over the surfaces. Attractive atomic forces between the atoms on the surfaces and the polymer molecules line up and cause the glue to cling to the surfaces. When the polymer hardens, its polymer strands are no longer able to flow, and the surfaces are locked to the polymer between them. This explanation is a theory. Theories in science are ideas that are not directly observable, but have much evidence to support them and therefore they are believed to be true. Nevertheless, history shows that science changes and theories that worked well may be replaced with new ideas.

Procedure

1. Have the students make a saturated solution of borax by gradually adding borax powder to $^1/_4$ cup of water until no further borax can be dissolved.
2. Next have the students slowly stir casein into the borax solution until it makes a thick paste.
3. Have the students test the strength of their glue by gluing suitable porcelain or wooden objects together. They should allow the glue to cure for at least 24 hours.

Family Involvement

Send home recipes for other glues (see Extensions below) and bring products to class for comparative testing.

Christian Application

Science is based on careful observation of nature. Scientists are very creative in inventing explanations to explain how things work. The theory of how glues work may not be true but it is the best idea presently available and is very useful. Science changes when the theory cannot explain something that it should be able to include. Science is a human activity. God blesses us through it, but science does not produce absolute truth.

Extension

Glues can also be made of egg whites or of flour and water. To make egg white glue simply separate the white from the yolk of an egg and use as any other glue. Flour and water glue is made by slowly mixing water into a batch of flour until it becomes a slightly runny paste. Students could produce an interesting project by devising a test to compare the strengths of the glues. A standardized testing procedure could be developed through discussion by the class. It might involve suspending the glued objects and then tying a string to the other end. Standard weights could be added to the lower end until the bond breaks. There are a lot of problems in this testing that allow for creative thinking on the part of the students (and teacher). Results should be recorded.

References

Mebane, Robert. *Adventures with Atoms and Molecules (IV)*. Hillside, New Jersey: Enslow, 1992.
Sarquis, Mickey. *Partners for Terrific Science Teacher Resource Module; Plastics and Polymers*. Oxford, Ohio: Miami University, n.d.

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“*Nevertheless, history shows that science changes and theories that worked well may be replaced with new ideas.*”

6. Making a Continuous Thread From Food Wrap

Equipment Needed

Open sauce pan; heat source (hot plate, Bunsen burner, etc.); aluminum foil; 7"-15" of food wrap; tweezers; disposable stirring stick

Purpose

To show that polymers form long threads as they "tangle" about one another

Safety—Special Considerations

Recognize the dangers of having a hot plastic being drawn from a heated pan. At a grade school level this activity is best carried out as a demonstration in front of the room by the teacher.

The fumes will be toxic. Allow for good ventilation.

It is easy to scorch the polymer "soup" making an odor that may well make you less than popular among your colleagues. You must be able to keep a close watch on the pan.

Grade Level—Time Needed

Junior and senior high school; Time: 30 minutes

Background

Food wrap is made of low density polyethylene (LDPE) which is easily shaped and has a relatively low melting point. As the LDPE is melted, the polymer strands are freed but will tangle with each other due to the friction of sliding past one another. A good analogy would be trying to pull just one noodle out of a plate of spaghetti and getting four or five noodles tangled with your first noodle. A different process is used for nylon and other synthetic threads, although their chemical and physical make up are similar. Nylon is made by the interface formed between two chemicals.

Procedure

1. Line the sauce pan with foil. (Inevitably the last bit of plastic will burn on the bottom of the pan.)
2. Ball up the entire amount of plastic and heat in pan.
3. As plastic begins to melt turn heat to low and begin stirring.
4. Once a polymer puddle has formed in bottom pan, use a tweezer to catch a bit of the plastic from the center of the pan.
5. Slowly lift the plastic thread. If extracted steadily and carefully, a continuous thread will form.
6. Once the thread is several feet away from the pan it becomes cool enough to safely handle with bare hands. With the help of several students supporting the thread, it should be possible to reach lengths of 30" or more. Additional plastic may be added to the pan as the thread is extracted if the supply runs low.

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7. Slime!

Equipment Needed

Water; graduated cylinder or paper cups marked by teacher at 15, 20, 30, 50, and 80 ml; paper cups for mixing; medium zippered plastic bags; stirring sticks; borax solution (made ahead of time by mixing 40 g [$^{1}/_{3}$ cup] laundry borax in one liter [one qt] water); measuring spoons, goggles The guar gum and polyvinyl alcohol mentioned below is available from chemical supply houses such as Flinn Scientific, P.O. Box 219, Batavia, IL 60510.

Purpose

To have the students see how a polymer gels as its strands are cross linked (See the unit introduction for an explanation of cross linking.)

Safety—Special Considerations

Your students will be working with chemicals that require eye protection. You may wish to add color to your slime by adding food coloring. Be advised that the freshly colored slime may stain clothes. If slime is spilled on carpeting, the stain can be removed by immediately using straight vinegar followed by soap and water. Older clothes and aprons are recommended.

Because slime is a substance that will be widely handled, some teachers like to add a drop or two of disinfectant such as Lysol.

Some people develop an allergic reaction to dry borax. Handle the borax with care to avoid its becoming airborne and avoid inhaling. It may be best to prepare the solution before class.

Because this activity has become such a popular way of allowing students to make and handle a polymer, many recipes have been developed. Several have been included for your choosing. Some teachers have their classes use a variety of recipes and hold a competition to judge the best slime according to predetermined criteria.

Grade Level—Time Needed

Intermediate through high school; Time: 15 minutes for each recipe

Background

Guar gum, polyvinyl alcohol and white glue (which is made from polyvinyl acetate) are all liquid polymers. The borax or starch contain molecules that form cross links between the polymer strands. (See the Polymers introduction for an explanation of cross linking.)

Polymer cross linking can be demonstrated by having two lines of students form two polymer strands by joining hands. Note how the chains are somewhat flexible and able to move about. If, however, two or three more students cross link the two chains together by grabbing the hands of students toward the middle of both chains, the chains become jelled. Now the cross linked chains cannot move about as easily.

The ability of the Gluoop to bounce makes it a good example of a non-Newtonian fluid— a fluid which acts contrary to the physics of Isaac Newton. Non-Newtonian fluids will slowly flow and flatten themselves if left undisturbed. These fluids act differently, though, when subjected to sudden energy (such as being thrown on the floor). Rather than flattening they become rigid and redirect the energy by rebounding.

Procedure

Guar Gum Slime

Materials needed per student/group:

0.75 g (1/4 tsp) guar gum

20 ml borax solution

1. Pour 80 ml of water into paper cup and stir in 0.75 g (1/4 tsp) guar gum until it dissolves.
2. Continue stirring and add 30 ml (two tbsp) borax solution
3. Add no more than two drops of food coloring (optional)
4. Once gel has formed, remove slime from cup and knead in your hands (It may take several minutes for gel to set.)
5. Store slime in zippered plastic bag

Polyvinyl Alcohol Slime

Materials needed per student/group:

30 ml (two tbsp) polyvinyl alcohol solution (PVA) — see directions below for preparing PVA if purchased in powdered form.

three ml (1/2 tsp) borax solution

1. Pour 30 ml PVA solution into cup
2. Stir in 3 ml borax solution
3. Add no more than two drops of food coloring (optional)
4. Once gel has formed, remove slime from cup and knead in your hands (It may take several minutes for gel to set.)
5. Store slime in zippered plastic bag.

Preparing PVA Solution:

To make a PVA solution from powdered PVA, add 1/3 cup of powder to one quart of water in a microwave-safe continuer. Heat on the **high** setting for eight minutes, stopping every minute or so to stir. You can also cook the PVA on a stove top instead of a microwave for 30-45 minutes at a moderate heat until the solution turns clear. Any skin that may form on the top may be skimmed off and discarded.

Gluoop #1

Gluoop has many of the same properties as Silly Putty™ including being able to lift water soluble ink and newsprint and make a reverse image on itself. It can be shaped into a ball and be bounced off the floor.

Materials needed per student/group:

30 ml (two tbsp) 50% white glue solution (prepare ahead of class by mixing equal parts glue and water)

15 ml (one tbsp) liquid starch

Combine the ingredients above using the same procedure as previous slimes.

Gluoop #2

Materials needed per student/group:

30 ml (two tbsp) 50% glue solution

10 mL (two tsp) borax solution

Combine the ingredients above using the same procedure as previous slimes.

References

Sarquis, Mickey. *Partners for Terrific Science Teacher Resource Module; Plastics and Polymers.* Oxford, Ohio: Miami University, n.d.

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8. Making Erasers

Equipment Needed

15 ml (one tbsp) liquid latex (available from chemical supply houses such as Flinn Scientific, P.O. Box 219, Batavia, IL 60510); 15 ml water; 15 ml vinegar; two disposable mixing cups; sink or bucket filled with water (one needed per class); tablespoon for measuring or graduated cylinder; mixing stick; goggles

Purpose

To examine how a natural polymer is a product used every day
To produce a useful item using the acid + base = neutral principal

Safety—Special Considerations

The liquid latex contains a dilute ammonia. Though it is in weak solution, it should still be respected as potentially harmful and eye protection should be worn. The fumes may also present a hazard to the eyes—especially to those wearing contacts since the gaseous ammonia may actually condense on the contact lens. Contacts should not be worn. If accidental eye contact is made, rinse affected area with water for 15 minutes and seek medical attention. Tell the students not to rub their eyes as they work. They might transfer chemicals from their hands to their eyes.

When latex gels, there is no safe way to remove the latex from hair, clothes or fabric. Old clothes, aprons or smocks should be worn. Large old white shirts make good lab coats.

Unused latex may be stored for later use. The small amount left on the sides or bottom of mixing container should be allowed to dry and peeled out later if container is non-disposable.

Grade Level—Time Needed

Junior-senior high; Time: 30-40 minutes

Background

Latex is the sap of the rubber tree originally found in the Amazon region. The sap is produced by the tree to form plugs which seal any injuries to its bark. Latex is called rubber since its earliest use was to "rub" off pencil marks. Today's erasers still use this latex base with the addition of vegetable oil, coloring, etc. Ink erasers have pumice (volcanic rock) added to them. A plant in the United States that has latex is the milkweed (which monarch butterflies lay their eggs on).

Rubbers lose their elasticity with use and are degraded by air and sunlight. Everyone has probably experienced having an old eraser on a pencil and wondered about why that happened.

The latex polymer molecule is a giant macromolecule called polyisoprene (polly ICE oh preen). These molecules can have a molecular weight of several thousand to several million. A useful way of thinking about the structure of polyisoprene (polly ICE oh preen) is to compare it to a bundle of wiggling snakes. When the bundle is stretched and released, it returns to its original length. Vulcanizing rubber (a chemical process) increases the number of cross-links and makes it more elastic. Adding carbon black reinforces the open spaces between the snakes to give them more strength and wear resistance for such uses as automobile tires.

The sap is harvested from the trees much like maple syrup. It is stored in a dilute ammonia solution since exposure to the air would cause it to quickly harden. When the acid vinegar is added to the liquid latex, the base ammonia is neutralized allowing the latex to harden.

Procedure

1. Before class, dispense 15 ml of latex solution and 15 ml of water into a labeled cup. Pour 15 ml of vinegar into a separate label cup for each student/group. Do not dispense the latex more than 10 minutes ahead of time or it will begin to gel.
2. Tell the class that they will be making erasers and that they should think about the shape that they would like to make.
3. Have the students slowly stir the latex/water mixture into the vinegar.
4. Immediately remove latex and rinse with water. Carefully knead out any bubbles by kneading latex as it is rinsed. Beware of spattering latex on clothing or in eyes.
5. Squeeze out excess water.
6. Shape into the desired form and allow the eraser to dry for 2-3 hours.

Christian Application

Latex's ability to form this rubbery plug is the method God built into the rubber tree to heal itself. The physical nature of this polymer makes a natural defense for the tree. This is a gift that God has given to some plants. He has given different gifts to different organisms. Everything that God has created has value in itself but is also a possible resource for us. When we use the Creation, we must be careful that we carry out sustainable activities. We must ask if the activities are something that we can continue to do at a particular level without causing harm to the Creation. For example, what to do with our old automobile tires has become a problem. People have come up with some interesting ideas.

Extension

The history of rubber is fascinating. The development of the automobile was revolutionized in 1839 when Goodyear developed a vulcanization process and developed a tougher rubber. In this process sulfur was used as the cross linker. Later other chemicals were used. There is also some interesting history involving the demand for latex and controlling the areas of Brazil and Malaysia where the rubber trees grow. World War II cut off the supply of rubber from the Far East to the United States. Students could investigate what happened on a personal level in the U.S. by interviewing older people who lived through it. (Tires were rationed and were also of poor quality. Gasoline and many other things were also rationed; therefore personal travel was limited. Efforts were made to find substitutes for tropical latex. In the process many other interesting polymers were developed.) The idea of rationing particular items and how the process worked could be fascinating to young people who have not experienced such strong government controls.

Students might be asked to investigate possible uses for old automobile tires.

References

Sarquis, Mickey. *Partners for Terrific Science Teacher Resource Module: Plastics and Polymers*. Oxford, Ohio: Miami University, n.d.

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9. Super Balls

Equipment Needed

10 ml (two tsp) sodium silicate solution (sold in many hardware stores as water glass; also available from chemical supply houses such as Flinn Scientific, P.O. Box 219, Batavia, IL 60510); 2.5 ml ($^{1}/_{2}$ tsp) isopropyl alcohol (sold in pharmacies as rubbing alcohol); measuring spoons or calibrated cylinders; small mixing cup; cup $^{1}/_{2}$ filled with water; plastic gloves or plastic bags which can be worn over hands as gloves; zippered bag; goggles; water; stirring stick

Purpose

To show the production of silicone, demonstrate cross linking and the nature of non-Newtonian fluid, and give an example of a synthetic polymer

Safety—Special Considerations

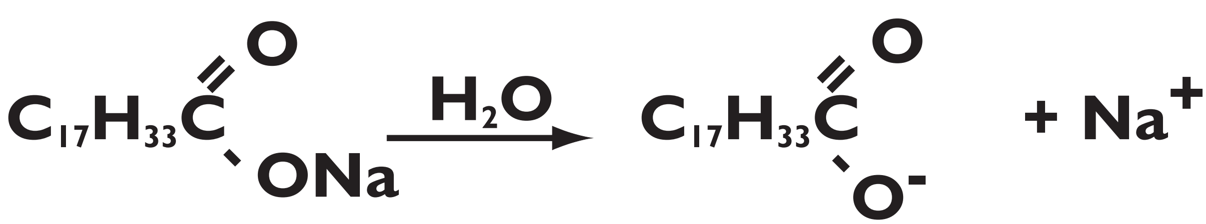
Alcohol is toxic and flammable; exercise appropriate precautions. Sodium silicate in its liquid form is not only toxic but also irritating to most skin. Hands should be protected by gloves during the lab and washed afterward.

Grade Level—Time Needed

Junior-senior high; Time: 15 minutes

Background

Sodium silicate mixes with the alcohol to form the long silicone polymers. Some of the alcohol molecules become cross linkers rather than becoming part of the strand. This polymer is different from the previously discussed polymers since it has a silicate rather than a carbon as its back bone giving it unique non-Newtonian properties. (See the background section of the Slime! activity (#7) for a discussion of non-Newtonian fluids.) It is interesting to note the structural similarities between carbon and silicon. Both tend to form four chemical bonds. Their close placement on the periodic table shows their similarities. A model of the reaction may look like this:



Procedure

1. Wearing plastic gloves, measure 10 ml of sodium silicate into paper cup
2. Premeasure, then quickly stir in 2.5 ml alcohol.
3. Speed is important—stir for only three seconds and pour the forming solid into gloved hand.
4. Gently press the polymer mass into a ball shape until it no longer crumbles. Occasionally moisten the ball by dipping it in water.
5. The ball will be ready for bouncing almost immediately.
6. Store in a zippered plastic bag over night. You may wish to hang the bags since the ball will flatten and become difficult to reshape.

Extension

Students who are able to grasp the reaction illustrated above may well be ready for a discussion about the differences between organic and inorganic chemistry. This is the only polymer of this unit that isn't carbon based

References

Sarquis, Mickey. *Partners for Terrific Science Teacher Resource Module; Plastics and Polymers*. Oxford, Ohio: Miami University, n.d.

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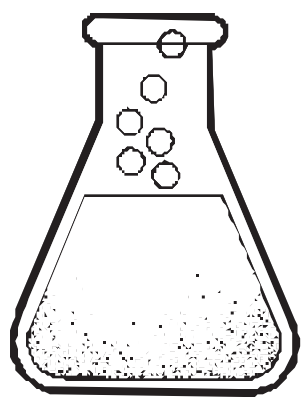

10. Find Poly

Equipment Needed

"Where Is Poly Now" worksheet and a variety of plastic goods found at home for identification.

Purpose

To make the children aware of how many of their materials at home are made of polymers and to become familiar with the different variety of polymers

Grade Level—Time Needed

Middle grades through high school; Time: 30-40 minutes

Background

Discuss the types of polymers and where to find the identifying recycling mark on the bottom of plastic goods. Some children may already be aware of reading the recycling mark on the bottom of plastic goods since municipalities may offer curb side recyclables pick-up, but only of specific plastics.

When the children return on the following day with their sheets, follow up activities may include: combining everyone's results, graphing or charting the percentages of the most often used polymers, and discussing why recycling is helpful to the Earth's resources.

Define waste and trash as resources that are out of place.

Ask the students if we can throw something away. What does this statement mean? Is there an "away"?

Assignment

See attached worksheet.

Family Involvement

Have the home survey completed by the family. It may also be presented as a scavenger hunt.

Christian Application

Part of good stewardship includes the careful use of our resources. In many communities there are no excuses for placing these plastics in landfills where the energy and materials they represent are as good as lost forever.

It is a gross misunderstanding of Scripture to believe that we can do as we please with the resources on God's Earth. We are to be stewards of the Earth. Our activities should be sustainable.

Extension

Recycling activities are almost limitless. Reports, field trips, and small recycling programs would represent just tip of the iceberg of activities possible.

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Where is Poly Now?

Help Poly find some of her long lost relatives by looking for plastic containers in your cupboards, recycling bins, etc.

Check the bottom of each of the items to see which type of plastic you found. You'll see a number enclosed in a triangle made of arrows. Use this sheet to tally all the different types of plastics you found.

Tally marks (total)	Symbol	Code	Material
	1	PETE	Polyethylene terephthalate
	2	HDPE	High-density polyethylene
	3	V	Vinyl/polyvinyl chloride (PVC)
	4	LDPE	Low-density polyethylene
	5	PP	Polypropylene
	6	PS	Polystyrene
	7	Other	All other resins and layered multimaterial

11. Making a Polyvinyl Interface

Equipment Needed

50 ml 4% polyvinyl alcohol solution (see Lesson “Slimes!” for preparation of PVA solution); 50 ml acetone (available at hardware and paint stores); 150 ml beaker; tweezers or forceps; stirring rod or plastic spoon; aluminum foil; goggles; (Optional) shallow aluminum pan; needle-less syringe such as a glue syringe

Purpose

To demonstrate polymer fiber production from an interface formed between two layers of chemicals

Safety—Special Considerations

Acetone is flammable and produces irritating fumes. Use in a well-ventilated area and wear eye protection.

Grade Level—Time Needed

Junior and senior high school; Time: 20-30 minutes

Background

Acetone acts as a “drier” by chemically pulling the water out of the PVA it contacts. The interface formed when the polymer strands of the PVA touched the layer of acetone above it. As the strand was pulled through the layer of acetone, it was further hardened as more of the water was extracted. Because the strands were pulled, the polymer fibers were able to tangle about each other and form an inelastic strand. Dipping the strand in water gives it back its elasticity.

Procedure

Do as a teacher demonstration.

1. Pour 50 ml of the PVA solution into beaker. The depth of the solution should be around two cm.
2. Add the acetone to the beaker by tipping it so that the acetone may be poured down the side of the beaker causing minimum disturbance to the PVA. Since these chemicals do not mix you should have two separate layers.
3. A white interface or layer will immediately form between the layers. Using the tweezers, gently pick a bit from the center of the interface and slowly and steadily remove. Usually a 1-2 foot fiber can be extracted to the amazement of the class. Keep pulling fibers from the interface until the PVA is gone.
4. Leave the strands on foil to dry overnight.
   (optional)
5. Pour a thin layer of additional PVA solution into a shallow disposable pan and allow to harden overnight into PVA disk.
6. Cut strand out of disk and compare to the interface strands. Check for strength and flexibility.
7. PVA can also be extruded to form fibers. Fill a syringe and push 2-3 inch fibers into a small, shallow pan. After several minutes the PVA stands may be placed into a shallow pan of acetone to harden.

Extension

Compare the way this synthetic thread is made to the way nylon is made.

References

Sarquis, Mickey. *Partners for Terrific Science Teacher Resource Module: Plastics and Polymers.* Oxford, Ohio: Miami University, n.d.

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12. Microscale Chemistry: Bleaching Action

Equipment Needed

1x8 microstrip, three thin-stem beral pipets, yellow and green food color in dropper bottles, household bleach, metric measuring device for liquid volume, safety splash goggles, three 25 ml beakers or similar containers

Purpose

To investigate the chemical properties of household bleach

Safety—Special Considerations

Household bleach should be handled carefully to avoid contact with clothing, skin and eyes. Even though student quantities are small, safety splash goggles should be worn.

Grade Level—Time Needed

Upper grades or high school; Time: 15-20 minutes

Background

The yellow color disappears and the green color turns blue. In both cases, the yellow color has been bleached out by the oxidizing action of the bleach. Bleach adds oxygen to the yellow pigment molecule. Adding the oxygen atom modifies the atomic structure. This change causes a change in the color. In the case with the green which is made of yellow and blue pigments, only the yellow pigment is affected with this amount of bleach.

Procedure

The teacher should prepare a classroom quantity of yellow and green colored water (one drop of food coloring for every 20 ml of water) and make an equal amount of household bleach available. Students should fill one beral pipet bulb with yellow water, another with green and a third with bleach. Use the pipets to load the wells as follows: First, load one well half full with yellow water. Next to it load another well half full with green water. Add equal drops of bleach to each of the two colors. Keep count. Tap the edge of the microstrip lightly to mix the bleach and food coloring.

Assignment

Students should record observations for the activity and develop a hypothesis which explains the observations. Discuss the uses of household bleach.

Christian Application

God has given us many wonderful chemicals and the knowledge to use them for our benefit. Discuss how a substance can be both useful and harmful depending on its use. Apply this concept to other substances. Why should some chemistry be done on a small scale? (danger from the energy released, less chemicals used).

Extension

Have students try different colors or color combinations. (Adding more bleach will eventually also remove the blue color.) The microstrip can be placed on edge on an overhead projector to display the results to an entire class.

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13. Macroscale Chemistry: Bleaching Action

Equipment Needed

Medicine dropper, yellow and green food color in dropper bottles, household bleach, tap water, metric measuring device for liquid volume, safety splash goggles, five 25 ml beakers or similar containers

Purpose

To investigate the chemical properties of household bleach

Safety—Special Considerations

Household bleach should be handled carefully to avoid contact with clothing, skin and eyes. Safety splash goggles should be worn.

Grade Level—Time Needed

Grades 5-12; Time: 15-20 minutes

Background

Bleach causes the yellow color to disappear and the green to turn to blue. In both cases, the yellow color has been bleached out by the oxidizing action of the bleach. Bleach adds oxygen to the yellow pigment molecule. Adding the oxygen atom modifies the atomic structure. This change causes a change in the reflected color. In the case with the green color which is made of yellow and blue pigments, only the yellow pigment is affected with this amount of bleach.

Procedure

Pour 20 ml tap water into two of the beakers; add two drops of yellow food coloring to each beaker. Next pour 20 ml tap water into two additional beakers; add two drops of green food coloring to each. Pour five ml bleach into the remaining beaker. Using the medicine dropper, add two drops of bleach to one of the beakers containing yellow water. Swirl or stir to mix the contents and observe. Repeat the procedure by adding two drops of bleach to one of the beakers containing green water. In each case, the untouched colored water in the remaining beaker serves as the experimental control for comparison purposes.

Assignment

Students should record observations for the activity and develop a hypothesis which explains the observations. Discuss the uses of household bleach.

Christian Application

God has given us many wonderful chemicals and the knowledge to use them for our benefit. Bleach is an example of such a substance. Discuss how bleach can be both useful and harmful depending on its use. Apply this concept to other substances.

Extension

Have students try different colors or color combinations. (Adding more bleach will also eventually remove the blue color.) The beakers can be placed on an overhead projector stage to use this activity as a demonstration to an entire class. Find some old yellow newspaper. Cut the paper into strips. Place them into bleach solution. Compare the color of the bleached paper to unbleached paper. Be careful not to get bleach on anything that you do not wish to change.

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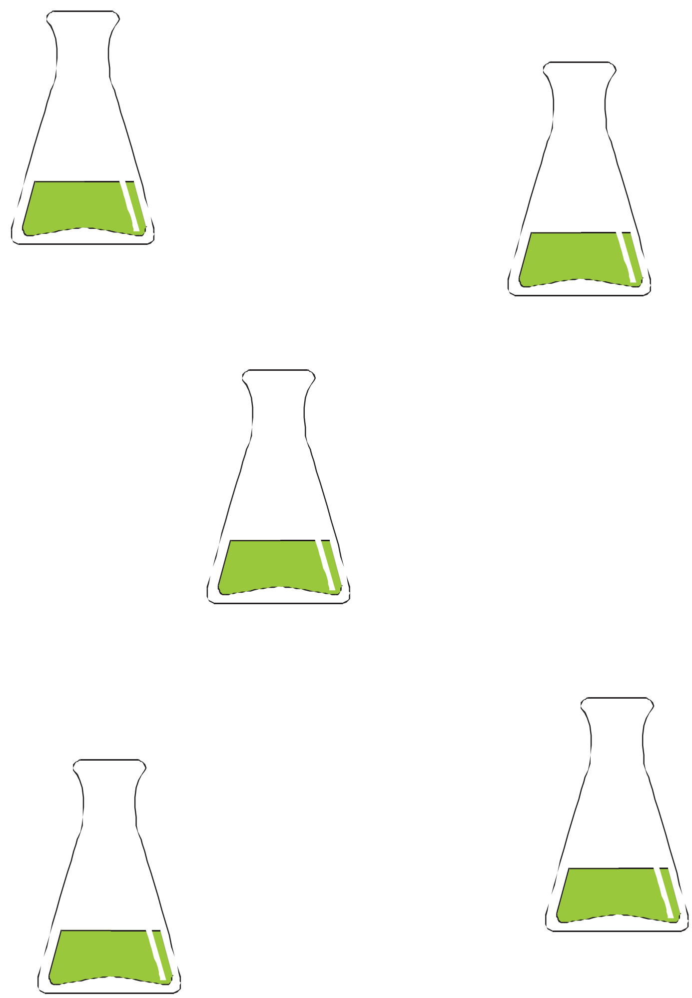

14. Activated Charcoal

Equipment Needed

Measuring cup, teaspoon, water, two small jars with lids, activated charcoal, blue food color

Purpose

To investigate the properties of activated charcoal

Safety—Special Considerations

There are no special precautions necessary with this activity.

Grade Level—Time Needed

Grades 5-12; Time: 15-20 minutes for set-up; four-day observation period

Background

The jar with no charcoal remains unchanged. The activated charcoal should gradually remove the food color from the other jar. The dye molecules are adsorbed by the activated charcoal. Activated charcoal is made by injecting steam into charcoal (a form of carbon) under high pressure. This makes the charcoal very rough and increases its surface area. A one gram piece of this charcoal has a surface area approximately equal to a football field.

Adsorption occurs when molecules are removed from a liquid or gas and stick on a solid. This process can be used to purify water and air. Activated charcoal is used in aquariums, tap water purifiers, and gas masks. This activity parallels what happens in an aquarium. The organic wastes produced by the aquarium organisms are filtered out by the activated charcoal.

Baby food jars work well for this activity. Activated charcoal is sold in pet shops for use in aquarium filters.

Note and teach the difference between "adsorb" and "absorb." A*d*sorb means that something has attached to something else. A*b*sorb means that something has moved inside something else. The blue pigment molecules are attached to the surface of he charcoal. They are a*d*sorbed. We hope that students will a*b*sorb something from this lesson.

Procedure

Fill a measuring cup with one-half cup of water. Add eight drops of blue food color to the water. Swirl or stir the water in the jar to mix the food color evenly. Pour one-fourth cup of the colored water into each of the two jars. Add two teaspoons of activated charcoal to one of the jars; tighten the lids on both jars. Observe the appearance of the water in the jars at regular intervals over a period of at least four days. (See Figure 1.)

Students should record observations over the period of the investigation and suggest a hypothesis for what is observed.

Christian Application

This activity serves as a model for water purification. Discuss the need for such a process in the drinking water supply for our cities. Concentrate on the proper stewardship of our resources and the Christian's role in the process.

Extension

This activity can be varied by trying different food colors in varied amounts. Discuss other allotropes (different structural forms) of carbon—cooking charcoal, diamonds, graphite, etc.

References

Mebane, Robert, and Thomas Rybolt. *Adventures with Atoms and Molecules. Book II.* Hillside, NJ: Enslow, 1987.

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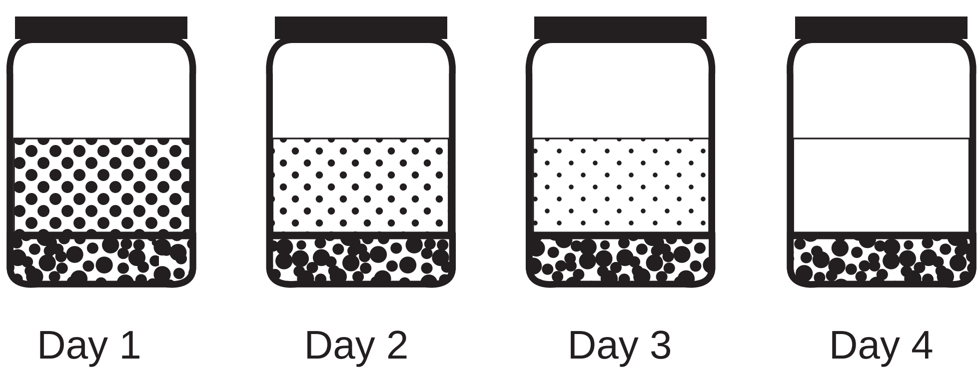
Figure 1

Charcoal removing dye molecules from water



15. Paper Chromatography of Food Coloring

Equipment Needed

Food color in dropper bottles, alcohol, pencil, paper clip, filter paper in strips 2 cm by 15 cm, paper toweling, clear plastic wrap, clear plastic cups or jars, metric ruler

Purpose

To separate a mixture of different molecules using a process called chromatography

Safety—Special Considerations

Prolonged contact between alcohol and the skin should be avoided. Wash hands after the activity. Eye protection should be used.

Grade Level—Time Needed

Grades 5-12; Time: 30 minutes

Background

The technique used in this activity is a form of chromatography, or color writing. To separate different molecules by chromatography, the mixture of molecules is placed on a material called an adsorbent (the filter paper). The molecules stick to the adsorbent until a solvent is allowed to pass through it. In this activity, the solvent moves through the adsorbent by capillary action. As the solvent moves through the adsorbent, some of the molecules are more strongly attracted by the solvent, others by the adsorbent. Picture it as a tug of war. These differences in attraction cause the molecules to separate if a mixture is present.

The alcohol used can be isopropanol (rubbing alcohol) or ethanol. The rubbing alcohol can be diluted from the 70% level as purchased to about 50% by adding 50 ml water for every 100 ml alcohol used. Clear unbreakable plastic drinking cups about 8 ounces in size work best. The filter paper can be made from coffee filters or a good grade of white paper toweling. Cut into 2 cm x 15 cm strips.

This activity can be used when studying mixtures or solutions and solubility. It also makes an interesting science fair activity which students can perform at home on their own.

Procedure

Fill the cup with alcohol solution to a depth of about two cm. Temporarily cover the cup with the clear plastic wrap to allow the alcohol vapors to saturate the space above the solution in the cup while you continue with the next step. Obtain a strip of filter paper and place a pencil mark on it about two cm from one end. Choose a color of food coloring and place a small amount, a spot about one cm in diameter, on the pencil mark. Let the spot dry. Remove the plastic wrap from the cup. Use the pencil to suspend the filter paper in the cup (Figure 1) allowing the paper to touch the alcohol solution, but not the bottom or sides of the cup. Also, do not let the food coloring spot touch the alcohol solution yet. Recover the cup with the plastic wrap. Allow the apparatus to stand for 10-20 minutes, or until the food coloring has clearly separated into its components. Remove the paper strip and place it on the paper towel to dry. (See Figure 1.)

Assignment

Students should observe and record observations. Have them identify whether the color they tested was a single color or a mixture of colors.

Christian Application

This is good activity to illustrate a physical change in contrast to a chemical change or a nuclear change. Discuss the fact that these are the three basic types of changes which man has discovered in the world God has created for us. This activity also identifies the fact that a few basic pigments can produce the full range of color we enjoy in the world. The gift of color and its accompanying variety are a marvelous gift from God. We have used our God-given intelligence to apply these concepts to the use of color in products we buy for our use (fabric, paints, etc.).

Extension

The food coloring can be mixed to produce shades in addition to the standard red, blue, green and yellow. Some brands of food coloring have charts on the package to give directions for this. Try the activity with marking pens. The solvents used could also be varied and results compared.

References

Allison, Linda, and David Katz. *Gee Whiz!* New York: Little Brown. 1983.

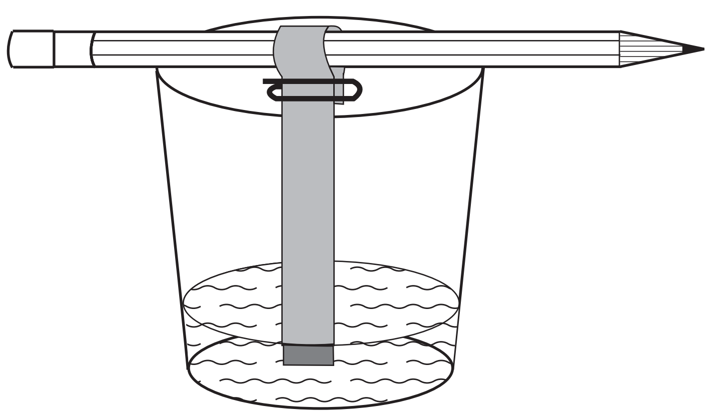
Charmichael, L. Neal, David Haines, and Robert Smoot. *Laboratory Chemistry*. Columbus, Ohio: Charles Merrill. 1979.

Mebane, Robert, and Thomas Rybolt. *Adventures with Atoms and Molecules. Book I.* Hillside, NJ: Enslow. 1985.

ST

Figure 1

Chromatography



16. Density Column

Equipment Needed

18 x 150 mm test tube, test tube rack, red food coloring in a dropper bottle, water, vegetable oil, dish detergent (preferably something green or blue for visual effect), corn syrup, metric measuring device for liquid volume

Purpose

To investigate the properties of several different liquids

Safety—Special Considerations

Since these are all household products which are safe for contact with the skin, no special precautions are necessary.

Grade Level—Time Needed

Grades 5-12; Time: 15 minutes

Background

Substances sink because of their density. The corn syrup is most dense and will sink to the bottom, followed by the dish detergent, the colored water, and the vegetable oil on top. Generally, substances will mix or separate depending on whether the molecules are similar or not. Oils and fats mix well because their molecules are non-polar and do not form ions. Water and ionic compounds form the other group. Water is polar. Detergents have both properties. If the setup is stirred, it will all mix because of the detergent.

Procedure

Add about 3 ml of each liquid to the test tube in this order by carefully pouring down the inside edge of the glass:

- water with red food coloring
- vegetable oil
- corn syrup
- dish detergent

Have students make predictions as they proceed. Place the test tube in the rack for final observation.

Assignment

Students should record predictions and observations as they proceed. Older students may offer an hypothesis for what they observe.

Christian Application

Discuss the various properties of these substances with students. Note similarities and differences. Elicit responses from the students that reflect a knowledge of God's wisdom in creating the framework which allows us to use natural substances for our benefit and to develop synthetic substances to make our lives easier.

Extension

Test different liquids. (Add an additional drop of food coloring to the finished column.) Experiment with different color effects and try floating small solid objects to see where they rest when dropped into the test tube. This can be used on a larger scale as a class demonstration.

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17. Cartesian Diver

Equipment Needed

Two-liter or smaller plastic soda bottle, disposable plastic thin stem beral-type pipets, hex nuts to fit the stem of the beral pipet, plastic ice cream pail or container for water

Purpose

To apply the scientific method; to investigate the properties of density, buoyancy, pressure, and the physical properties of liquids and gases

Safety—Special Considerations

There are no special precautions necessary for this activity.

Grade Level—Time Needed

Grades 5-12; Time: 20 minutes

Background

Keep in mind that air is very compressible; water is practically incompressible. Hence, water transfers force well.

There are at least two appropriate explanations to this phenomena, both based on the concept of density=mass/volume. First, as the bottle is squeezed, the air inside the diver is compressed and more water is forced inside. The increased mass and decreased volume increases density and makes the diver sink. As pressure is released, the water escapes and the diver once again floats. A second explanation applies if the opening on the diver is sealed. When the bottle is squeezed, it compresses the air pocket inside the diver and decreases its total volume. Even though the mass remains constant in this case, the decreased volume increases density. Again the diver sinks. Tip: Although you may want to let your students discover this for themselves, it is best to completely fill the soda bottle with water; that way, squeezing the bottle will transfer pressure to the air inside the diver rather than the air pocket at the top of the bottle.

Scientists often think about systems. The diver is a good example. The density of the system is varied by the pressure. This is counter-intuitive because the system is open.

Procedure

Cut off all but 15 mm of the pipet stem. Screw the hex nut onto the stem as far as it will go. This will be used as ballast (see Figure 1). Test the pipet in water to see if it will float upright; if it will not float, add hex nuts until it does. Squeeze out some of the air and draw in water. Adjust the amount of water drawn in until the pipet just barely floats. If it sinks to the bottom, it is too heavy; squeeze out a little water. When you have finished fine tuning the pipet, place it in the soda bottle filled with water and screw the cap on securely. Now squeeze the bottle—watch the pipet dive! Release the pressure—watch it return to the surface.

A third alternate method is to use a medicine dropper in the plastic pop bottle.

Assignment

Have students build a diver following the teacher's instructions. After testing the diver, students should discuss their observations and hypothesize about its operation.

Christian Application

This process also explains the mechanism used by some fish for surfacing and returning to the depths of their water environment. Many bony fish have swim bladders. Air in the swim bladder creates a body density nearly equal to the density of the water. At greater depths of water, the fish increases the air in the bladder to counter the increase pressure. Conversely at a shallow depth, the fish releases air to adjust to less water pressure. Having a density nearly equal to water makes movement easier. Fish with swim bladders expend 20% less energy than fish without swim bladders. Having a variety of fish, with and without swim bladders, enriches the balance of fish throughout the aquatic ecosystem. In creating ecosystems, God through this type of mechanism provides for the preservation of various creatures. When we study nature, we can see the same simple concepts applied in many different ways.

Extension

Have students try multiple divers, decorated divers, sealed divers with food coloring inside, etc. This can be an excellent activity to stimulate creativity. Divers can be made of pen caps weighted with modeling clay or soda straws cut to a length of 8-10 cm, folded in half, clipped with a bobby pin and weighted with paper clips. (See Figure 2.)

Let a diver remain in the classroom for a day or two. The diver will sink. Ask the students to determine the cause. (The air in the diver has dissolved into the water.)

References

Bob Becker, Kirkwood High School, Kirkwood, MO.

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Cartesian Divers

Figure 1

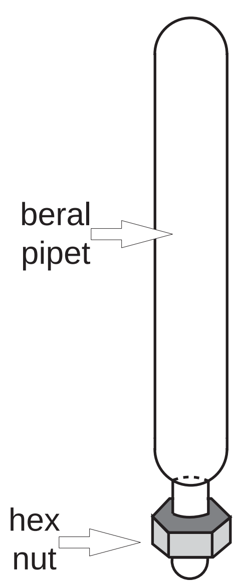
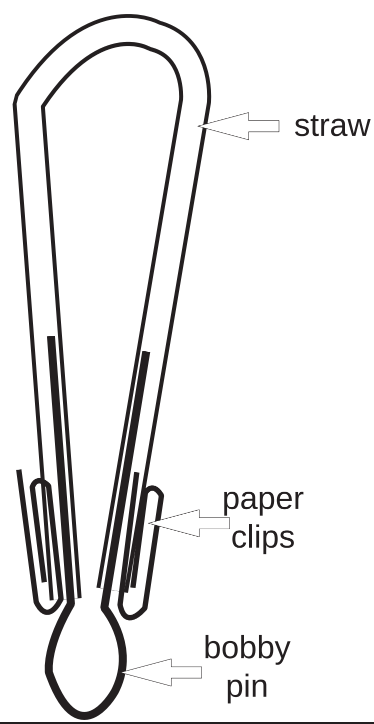


Figure 2



18. Easter Egg Dyeing

Equipment Needed

Four-hard boiled eggs, food coloring, hot water, vinegar, cup (large enough to contain the egg), clock or timer, measuring cup, paper toweling, adhesive labels and marking pen, measuring teaspoon, egg carton

Purpose

To investigate the use of vinegar in the dyeing of eggs

Safety—Special Considerations

Although the products used are common household substances, splashing the dye solution or its components should be avoided to prevent contact with eyes or clothing.

Grade Level—Time Needed

Grades 5-12; Time: 30 minutes

Background

Students have probably dyed Easter eggs and know that vinegar is used. To introduce this activity and get them thinking, ask them to develop a hypothesis which suggests why it is used.

The eggs dyed with a full teaspoon of vinegar should be the darkest; the one without vinegar is the lightest; the others, predictably, lie somewhere in between the extremes. When an egg is dyed, food coloring molecules stick to a layer of molecules which is found on the surface of the egg shell, called the cuticle. The surface of the egg contains protein molecules, large molecules made by living organisms. The hard material under the cuticle is mostly calcium carbonate. Vinegar is a dilute solution of acetic acid which can react with protein molecules. This reaction forms positive charges on the protein molecules. As the amount of vinegar is increased, the number of positive charges also increases. Food coloring molecules have a negatively-charged region. The positively-charged region of the protein molecules attracts this food coloring; the degree of attraction is affected by the amount of vinegar and the number of positive charges. In conclusion, the amount of food coloring molecules that bond to the surface of the eggshell increases with increasing amounts of vinegar. Of course, the vinegar also reacts with the calcium carbonate and will eventually remove the hard part of the shell.

Procedure

Divide the class into groups of eight students. Ideally students would work in pairs within those groups. Each pair of students within a group will follow the same procedure except for the amount of vinegar used. One pair will use one teaspoon of vinegar; the others will use one-half teaspoon, one-fourth teaspoon, and no vinegar, respectively. Each pair should use the adhesive label and marking pen to label their cup with the assigned amount. Each pair within a group should use the same color dye.

Once assignments are made, each group should proceed in a similar manner. Place one teaspoon of food coloring into the labeled cup. Obtain one-half cup hot tap water in the measuring cup and add it to the food coloring in the labeled cup. Add the assigned amount of vinegar to the labeled cup and mix thoroughly. Carefully place the egg into the labeled cup. Let it absorb the dye for 15 minutes. After 15 minutes, remove the egg from the dye, rinse it with tap water, and place it on the paper towel to dry.

After the egg is dry, place it into the egg carton for the group. Take the label off the cup and put it in position on the carton which corresponds with the appropriate egg. Compare the varying color intensity for each of the eggs.

Tips: The hot water should be uniform to achieve uniform results. With so many individuals involved in various parts of this activity, it is important to strive for as much uniformity as possible. Only one condition should be allowed to vary at one time in an experiment.

Assignment

Have the students record observations in groups and compare results. Also have them compare with other groups and with the original hypothesis.

Christian Application

This activity is a good one to develop the thought processes necessary in using the scientific method. Our God created the orderly environment we know as Earth for our welfare. At the same time, there are many mysteries which he does not reveal to us. The process of investigation used here is similar to that used in medical research.

Extension

Use a file to scratch the surface of one of the eggs prior to the dyeing process. This removes the cuticle and exposes calcium carbonate. Few if any positive charges result to attract the dye. The color is dull and pale.

References

Mebane, Robert, and Thomas Rybolt. *Adventures with Atoms and Molecules. Book II.* Hillside, NJ: Enslow Publishers, 1987.

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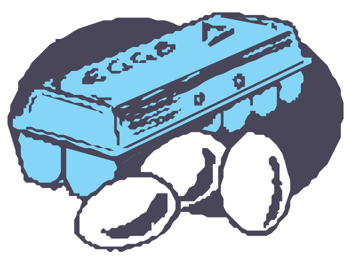

19. Hero's Fountain

Equipment Needed

Three two-liter soda bottles; three #3 rubber stoppers, 2-hole; 100 cm of glass tubing (6 mm outside diameter); 10' plastic tubing ($^{3}/_{8}$" outside diameter)

Purpose

To demonstrate how differences in atmospheric pressure can be used to create a water fountain

Safety—Special Considerations

Proper procedures and care should be exercised in preparation of the tubing and assembly of the fountain. Placing glass tubing into rubber stoppers is a major cause of injury. (See "General Guidelines for Science Safety" in the introduction to this text.) Be sure the tubing is cool. Use the back of the hand as a heat indicator. *Hot glass does not look hot.*

Grade Level—Time Needed

Grades 5-12; Time: 60 minutes to construct and test the fountain; 5 minutes to demonstrate

Background

Before water is added to the funnel, bottles A and B have the same atmospheric pressure. As the water drains down hose #1 into bottle B, it creates additional air pressure inside. Since the air pockets in bottles A and B are connected by hose #2, the pressure in bottle A will also increase. As the pressure in bottle A increases, water is pushed through the tube, creating a fountain. The water draining down from the funnel through hose #1 into bottle B is replaced by an approximately equal volume of water being recycled from the spray back into the bowl. Once the fountain is started, it will continue to run without additional priming until the water in bottle A runs out.

Procedure

1) Fountain construction

Cut the top third off one of the soda bottles. The other two should be left intact. Remove a 2-cm length from the plastic tubing and then cut the remaining tubing in half so you have two lengths of approximately five feet. Score and break the glass tubing into six pieces of the following lengths: 40 cm, 32 cm, 10 cm, and three 6-cm pieces. Fire polish all ends. Heat the center of the 10 cm length in a laboratory burner flame until the glass is soft and draw it out into a thin capillary tube. The smaller the diameter, the higher the fountain will spray. Let the tube cool, break it in half at the thinnest point, and fire polish the tapered tips briefly, being careful not to close them off. The tip of the tubing must be even and straight. Assemble the apparatus as pictured in the diagram (Figure 1). When you insert glass tubing, your hands must be covered with cloth. Also, hold your hands close to the stopper.

2) Fountain operation

Place the assembled apparatus on a table or counter. Fill bottle A with tap water. Check to be certain that all stoppers are inserted securely. To start the fountain, place the empty bottle B at a lower level on a chair or the floor. Fill the top funnel (C) with water. The fountain will begin to spurt within a few seconds and continue for at least 15-20 minutes. As the fountain begins to spurt, adjust the tip so the water returns to the system rather than spilling out.

Assignment

Challenge students to examine the setup, sketch it and explain its operation. See if they can identify the potential energy possessed by the water in bottle relative to bottle B below it as the source of energy necessary to drive the fountain.

Christian Application

When God created the earth he gave it to man for his use.This activity is one example of how man has been able to use his God-given intelligence to subdue the forces of nature for the very practical purpose of pumping water.

Extension

This activity can be used in connection with studies in atmospheric pressure. A discussion of manometers and barometers might also be applicable. Make the connection between this activity and the operation of drinking straws and siphons. The principle is the same.

References

Becker, Bob. *Flinn Fax*.Vol. 95-1. Batavia, IL: Flinn Scientific, Inc. 1995.

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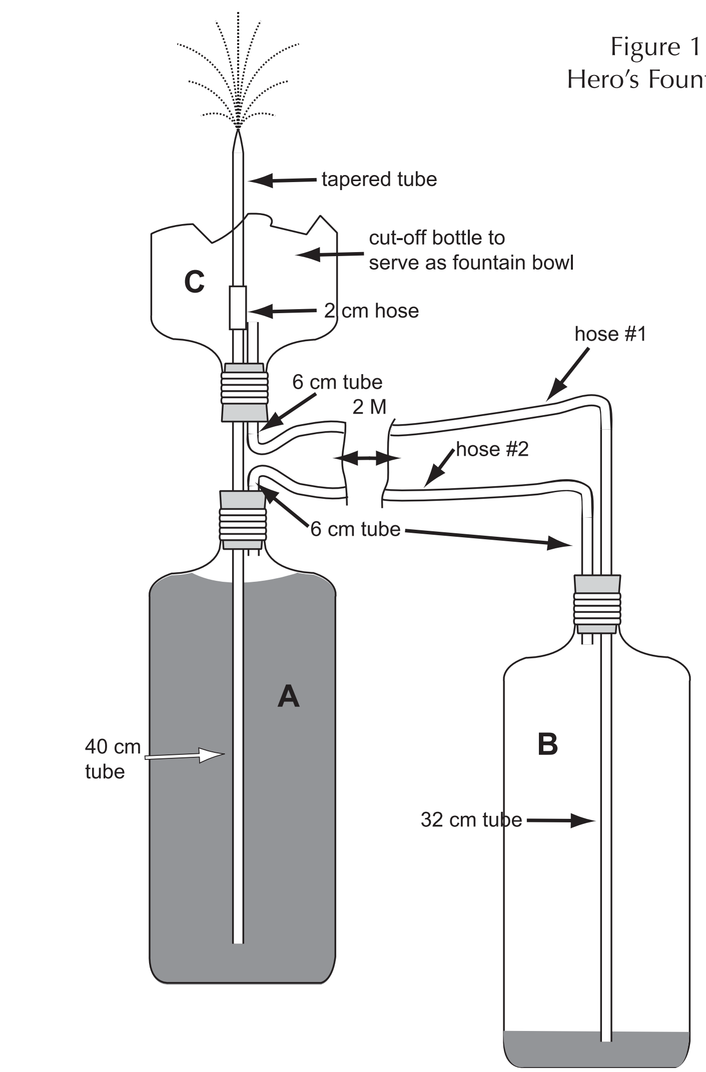
Figure 1
Hero's Fountain



20. Heat Treatment of Iron

Equipment Needed

Two iron bobby pins, forceps, 600 ml beaker, tap water, laboratory burner or butane lighter

Purpose

To investigate the effects of heat treatment on the properties of iron

Safety—Special Considerations

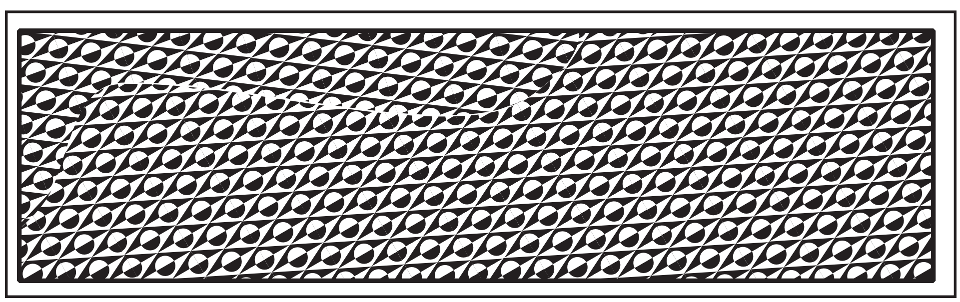
Since an open flame is used in this activity, adequate supervision should be provided. Follow the manufacturer's directions for safe operation of a butane lighter. Do not handle the metal until it has cooled adequately.

Grade Level—Time Needed

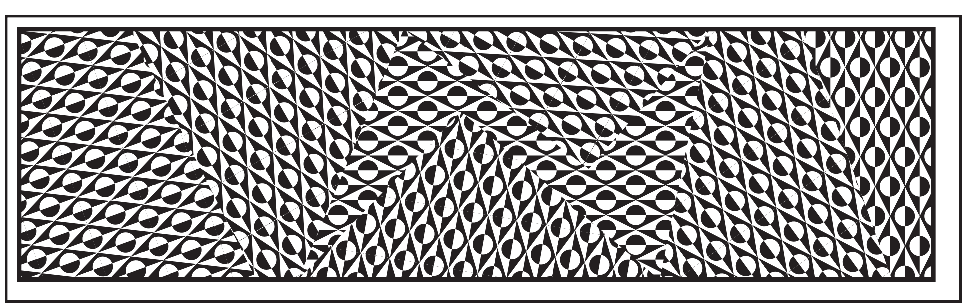
Grades 5-12; Time: 30 minutes

Background

Heating a metal to a red-hot temperature causes the metal atoms to move faster and more freely. Iron in this condition is easier to bend. By allowing a metal heated in this way to cool slowly, nearly perfect crystals of iron are formed (see diagram below). This process is called annealing. The more perfect the crystal of a metal, the easier it is to bend the metal because the atoms can slide over one another more easily.



When the red-hot, fast-moving atoms of iron are cooled quickly, they don't have enough time to form into large, ordered crystals. This results in defects that separate the many small crystal groupings (see diagram below). The iron, now hard and brittle, is said to be hardened. This type of iron is useful for making the edge of a knife blade.



The process of slowly warming a piece of metal after it has been hardened is referred to as tempering. This process removes the brittleness of the hardened metal and returns the spring.

The crystalline structure of the tempered iron is a cross between the more perfect crystals of annealed iron and the disorderly structure of hardened iron.

A butane lighter with an adjustable flame works better than the type which does not allow adjustment. Use the largest flame possible. A laboratory burner or a propane torch allow the entire bobby pin to be heated instead of a short segment.

Procedure

Examine one of the bobby pins. Try straightening it and note the degree of flexibility as you try bending it again. Ignite the heat source. If a butane lighter is used, students must work in pairs with one responsible for keeping the flame going. Grasp the open ends of a pin with your fingers and place the closed end into the hottest part of the burner flame. As the pin begins to glow, slowly pull on the ends to open the pin and straighten it. Remove it from the flame. Repeat this with the other pin. Pour 400 ml tap water into the 600 ml beaker. Holding a straightened pin with a forceps, remove the outer plastic protective coating by heating it in a flame and dropping it into the water in the beaker. Repeat the process with the second pin. Remove the pins from the water and use your fingers to flake off any excess coating from them.

Hold a straightened pin at the end with the forceps and heat the end until it glows red-hot. Let it cool slowly in air. Repeat this procedure with the other pin. When the pins have cooled, bend them into S-shaped hooks. Observe the degree of flexibility exhibited by the hooks and any other properties you may notice.

Place the beaker of water next to the flame source. Holding one of the hooks you've made with the tongs, heat it to a glowing red-hot appearance. **Quickly** cool it by dropping it into the beaker of cold water. Repeat this process with the other hook. Remove one of the hooks from the water. Try bending the part of the hook you heated and cooled back and forth. Note any new properties observed.

Remove the remaining hook from the water. Grasp it with the tongs and hold it a few inches above the visible part of the burner flame. Continue heating at a distance from the flame which allows the metal to turn an iridescent blue-gray color without ever glowing red-hot. Allow the hook to cool slowly in air. Try bending this hook. Note how similar its characteristics are to the original bobby pin.

Assignment

Record observations as the activity progresses. By comparing the properties of the metal in the various stages, tell whether you think the original bobby pin was annealed, hardened or tempered. Support your answer.

Christian Application

God has allowed us to use our knowledge to develop products which serve our needs.

Extension

The position of iron atoms in the various forms prepared in this activity can be illustrated for a class on an overhead projector. Use a large, clear plastic drawer from a hardware organizer. Fill the drawer three-fourths full with BBs. Annealing can be demonstrated by gently moving the BBs (representing iron atoms) into a position which is regular in pattern. Hardening can be illustrated by shaking the BBs and stopping abruptly. The position of BBs representing hardened iron can be modified to represent tempered iron by gently shaking a few (but not all) of the BBs into a regular pattern.

Discuss situations in which the various kinds of iron might be desirable, for example, the hardened edge of a knife blade.

References

Institute for Chemical Education, University of Wisconsin-Madison, n.d.

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21. The Margarine Puzzle

Equipment Needed

A $^{1}/_{4}$ pound stick of each of the three grades of margarine—regular, light and extra light. If possible, use the same brand for all three and save the cartons. Three 250 ml pyrex beakers or similar-sized microwaveable containers; three 100 ml graduated cylinders; butter knife; three Styrofoam meat trays; microwave oven, crayon

Purpose

To find out the differences among the three grades of margarine

Safety—Special Considerations

Proper procedure should be followed for use of the microwave oven. Handle the microwaved margarine carefully—it may be hot! Approach with the back of your hand as a heat indicator.

Grade Level—Time Needed

Grades 5-12; Time: 30 minutes

Background

When the margarine is placed in the microwave oven and melted, it separates into oil and water. You know the old saying, "Oil and water don't mix!" It soon becomes clear that the approach to making margarine lighter is to include less oil and more water. Typically, regular margarine is about 20% water; light margarines are about 40% water; finally, extra-light varieties are almost 60% water (and yet is usually the most expensive of the three!).

Procedure

Unwrap each of the margarine sticks and place them on individual Styrofoam trays. Cut each stick in half (width-wise) with the butter knife. Each stick should be the same length and the identities must not be confused. Noting the identities of the various grades, place each $^{1}/_{2}$ stick into its own beaker. Label each beaker with a crayon. Each beaker should be separately placed into the microwave and melted. Try 10-15 second intervals until all the sticks have melted—don't overheat. Pour each of the different margarine grades into separate graduated cylinders, again keeping the identities separate. Notice what has happened to each of the margarines. Compare among the three grades.

Assignment

Record observations throughout the activity (depending on the grade level, these may be qualitative, quantitative or both). Compare recorded observations with the labeling information on the margarine packages.

Christian Application

Our Lord encourages us to be good stewards of our bodies and our material resources. In our modern times, this includes becoming a label-reader and an informed consumer. This activity can serve as an incentive to be more careful about what we buy and what we eat.

Extension

The data could be illustrated by means of a graph. Cost analysis of the product might also be interesting (cost per gram of fat for each of the three grades). The water content of butter could be included as a part of the analysis. Students can investigate why some margarines have a warning which says, "Do not use for cooking."

If a microwave oven is not available, the margarine can also be melted by indirect application of heat from a stove or laboratory burner using a water bath.

References

Chem Matters. Washington, D.C.: American Chemical Society. October, 1990.

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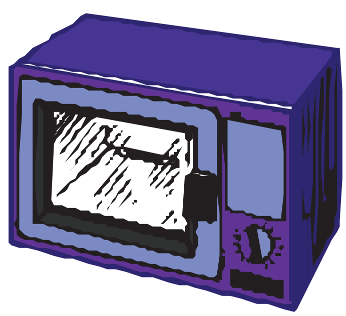


22. Investigate the Molecular Properties of Milk

Equipment Needed

For each group of up to four students—small bowl or jar lid (8-10 cm diameter); red, green, yellow and blue food color in dropper bottles; wooden toothpick; dish detergent; whole milk

Purpose

To improve scientific observation and investigation skills

Safety—Special Considerations

No special precautions are necessary.

Grade Level—Time Needed

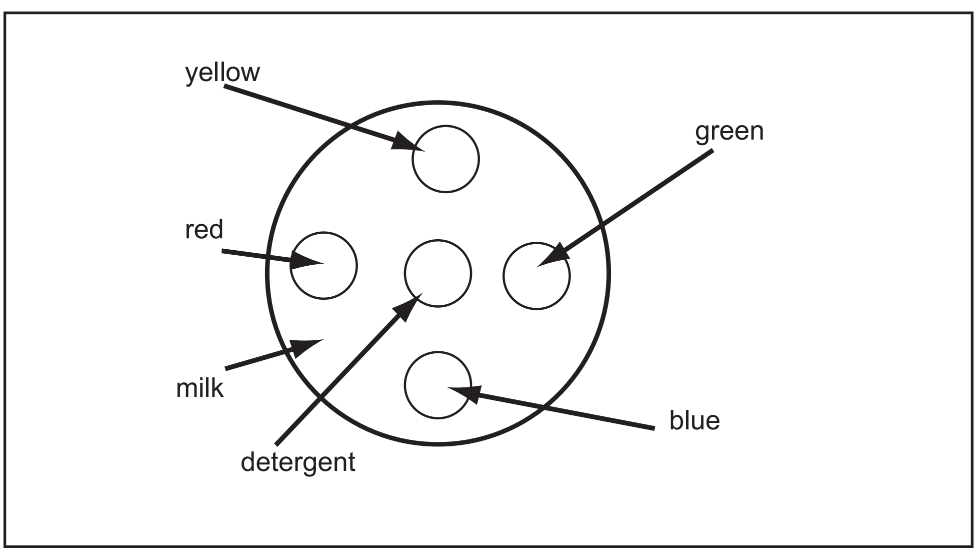
Grades 5-12; Time: 15-20 minutes

Background

Whole milk is a mixture of water molecules and fat molecules. Water is made up of polar molecules which have an unbalanced arrangement of atomic charges; fat molecules are non-polar molecules with a balanced arrangement. A detergent is generally a mixture of molecules which have both ionic (charged) end (attracting water which is polar) and a non-polar end (attracting fat). The swirling patterns which occur are the result of the detergent breaking the surface tension of the milk and the interaction between polar and non-polar molecules.

Procedure

Pour a small amount of room-temperature, whole milk into the small bowl or jar lid. Cover the lid surface. Allow it to stand for several minutes until the currents dissipate. Add a drop of each food color, evenly spaced around the outside edge of the container (see diagram below). Touch a clean toothpick to the center of the milk. Observe. Use the toothpick to place a drop of detergent into the milk at the center of the container. Observe. Add another drop and continue observations.



Assignment

Students should record observations, form a hypothesis which explains the observations, and use additional experimentation to test the hypothesis.

Christian Application

The polar properties of water are essential to life and responsible for many of water's unique characteristics. It is less dense as a solid than it is as a liquid. It is suitable for use as a solvent and it has a relatively high boiling point. The guiding hand and wisdom of God in creation are clearly seen through these characteristics.

Extension

A similar effect is seen when finely ground pepper is sprinkled over water in the bowl and interacted with the detergent on the toothpick.

References

Institute for Chemical Education. University of Wisconsin-Madison. n.d.

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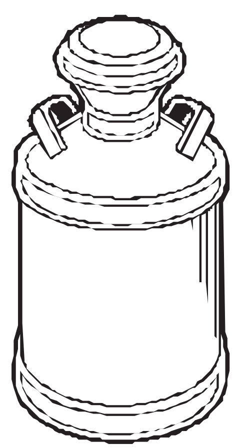


23. Viscosity Tester

Equipment Needed

Four small marbles, four large test tubes (at least 15 cm in length and a diameter large enough to allow a marble to be dropped through it), four rubber stoppers to fit test tubes, four liquids with different viscosities, Styrofoam meat tray, silicone adhesive

Purpose

To demonstrate that some common liquids have different viscosities

Safety—Special Considerations

Care should be exercised in pouring the various liquids. Any spills should be wiped up and hands should be washed after contact. Care should also be used in handling glass.

Grade Level—Time Needed

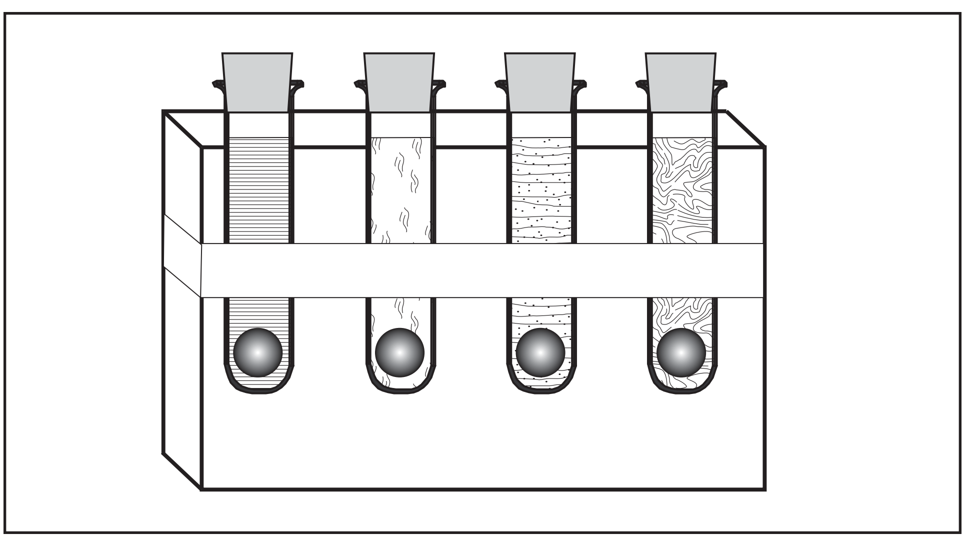
Grades 5-12; Time: two class periods of 15 minutes each (one to build and one to test the device)

Background

Viscosity (vis-KAHS-eh-tee)is a substance's resistance to flow. Viscosity is related to intermolecular attractions. Viscosity can also be affected by long molecules becoming tangled. The stronger the intermolecular forces of a substance, the greater its viscosity. In this test, water is the least viscous of the substances, followed by the vegetable oil, the detergent and the corn syrup. Students interested in auto mechanics may be familiar with this concept as it relates to the various grades of engine oil. Viscosity also varies with temperature. Less viscous (vis-KUSS) oils are used at lower temperatures to allow the engine to move with less resistance.

Procedure

Select four liquids with varying viscosities. Some good choices would be vegetable oil, dish detergent, corn syrup and tap water. Fill each of the four test tubes to within two cm of the top with one of the four liquids. Add a marble and seal with a rubber stopper. Use adhesive to permanently seal. Line the four test tubes up on the surface of the meat tray, positioning each one parallel to the next and at least two cm apart. (See diagram.) Use the adhesive to permanently



affix the tubes to the tray. Allow the adhesive to dry. You may want to label the various liquids in some way on the tester.

The next day the device may be tested. Invert the apparatus to get all the marbles at the same position in the various test tubes. Quickly flip the apparatus to allow the marbles to descend. Compare the rates of descent for the marbles in the various liquids. The slower the descent of the marble in the liquid, the greater the viscosity of the liquid.

Assignment

Students should construct the viscosity testers in small groups and compare the results of their tests. After the activity, students should be able to define viscosity and suggest the relative viscosities of these common substances.

Christian Application

There are many unique and interesting properties of matter which we take for granted. A further investigation of them makes us all the more aware of the complexity of God's creation.

Extension

We are all familiar with the expression slower than molasses in January. Have students discuss or test the relationship between viscosity and temperature. Be careful with the choice of liquids here. Some materials are flammable. Alcohols, oils, and solvents may ignite. Gentle warming with a water bath may work. A person must chooose carefully the material to be tested and handle it without being burned. Cooking oils with a moderate temperature range would work.

Other liquids to test could include rubbing alcohol and salt water (both mixtures). Different oils could also be compared. Although this activity is designed primarily to collect observations qualitatively, it could also be done quantitatively by timing the descent of each marble. The latter could include development of a data table and graphing the final outcome.

References

Mebane, Robert and Thomas Rybol. *Adventures with Atoms and Molecules. Book II.* Hillsdale, NJ: Enslow, 1987.

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24. Teaching the Periodic Table

Equipment Needed

Handouts on the period table

Purpose

To emphasize the principles and applications inherent in the period table
To demonstrate the value of the table for prediction of properties

Safety—Special Considerations

None

Grade Level—Time Needed

High school chemistry class; Time: 20 minutes, repeat many times at different levels during the course of the term

Background

The periodic nature of the elements was established by Mendeleev, Newlands, and Meyer in the 1870s. The study of chemistry would be hopelessly confusing if it were not for this most useful generalization: the properties of the elements are periodic functions of their atomic numbers (Mahan). The table illustrates the periodic function and is the paradigm in chemistry.

Mendeleev's table had holes and predicted elements that had not yet been discovered. He predicted the properties of these missing elements on the basis of their open positions in the table. When they were found, it turned out that he was amazingly close.

The use of this exercise is highly recommended because It is a powerful tool in developing an understanding of the workings of the periodic table. A version appeared in the back pages of *Chemistry* in 1968 which had been taken from the *Oregon Science Teacher,* without an author cited or comments about its applications in teaching. This writer found it to be extremely useful at both the high school and introductory college levels. The alternative practice, a memorizing of the first twenty elements is a fairly mindless activity that frightens many from any further study of chemistry (Orth). The basic idea of the actual use of the chart is to show the relationships, the big ideas, the principles.

Clues in the exercise can involve any of the following principles although you may choose to add others (cf. Mahan, 553-577). (1) Fundamentally, the table is organized **by mass** from smallest to largest. (2) A new row (period) begins whenever an inert element occurs. This results in defining periods and reveals repeating chemical behavior. Hence, columns tend to demonstrate the same chemical valence (combining ratio) and similar physical properties. Therefore, each column can be called a family or group. (3) There are regular trends in chemical and physical properties moving from element to element in any given column or row. (4) Metallic behavior increases as elements are located to the left and downward. Metals are electron-donors, conduct electricity and heat well, tend to have shiny surfaces (luster), can be drawn into wire (ductile), and are malleable. Nonmetallic properties, electron acceptors, increase as you move to the right and upward, not including column eight. Horizontal position trumps vertical position when two elements are at an adjacent diagonal such as elements 11 and 20. Element 11 is more metallic. (5) Column eight holds the inert gases. (6) Atomic number equals the number of electrons and also the number of protons. (7) Ionization energy (the energy required to remove an electron) increases along any row. (8) All else equal, the phase (gas, liquid, or solid) at a given temperature is influenced by the mass of the element. (9) Locations of the common diatomic molecules form a "seven" group on the chart, including N2, O2, F2 Cl2 Br2. I2 and At2. (Plus, do not forget H2). (10) Proximity on the chart predicts similarity.

All these principles form a valuable general reference to which there may, of course, be exceptions. Two sample tables with clues are included to illustrate some possibilities, but it is important that teachers construct their own exercises and control the content to directly reflect the scope and sequence in their courses.

Procedure

Construct two versions of the short form periodic table based on what has been taught in your class. There is no need to fill in every box on the table (although you will find that there are people who like that type of closure and assurance). Hand out one of the exercises and lead the class through it. Tell them that the transition series, elements 21-30, has been removed (This needs to be remembered in row four when some clues are constructed and used). Define the use of "row" and "column" and be consistent in the use of these words. Explain that the elements have been coded. The first clue is that each three-member group tends to share the same valence. Teach the students to write each three-member group below each column when clues indicate only general location. Then they can sort the members of each group out within the column as more information becomes available. Demonstrate how the exercise works. Think out loud and explain how each clue is used. Encourage questions and criticisms of clues. Make references to a real periodic chart.

This activity can be repeated many times during the teaching of high school chemistry. The content of the clues should be controlled by the teacher and based on what is being taught plus review items. Therefore, the variety of clues will increase as the course progresses. You can even invite students to make them up. The activity should also be included on tests.

Construct new exercises as the class progresses depending on what is being taught. The teacher should carefully fit the content of these exercises to the course.

Tell the students that this exercise deals with the underlying principles and applications of the periodic table. The table is very inclusive and powerful; it is the cornerstone of the current paradigm for chemistry.

Assignment

Hand out another table as a homework assignment.

Family Involvement

Tell students to show their parents how the assignment works. Others in the family that have taken chemistry will be especially interested.

Christian Application

The periodic table is our present understanding of the order that God has built into the creation.

Extension

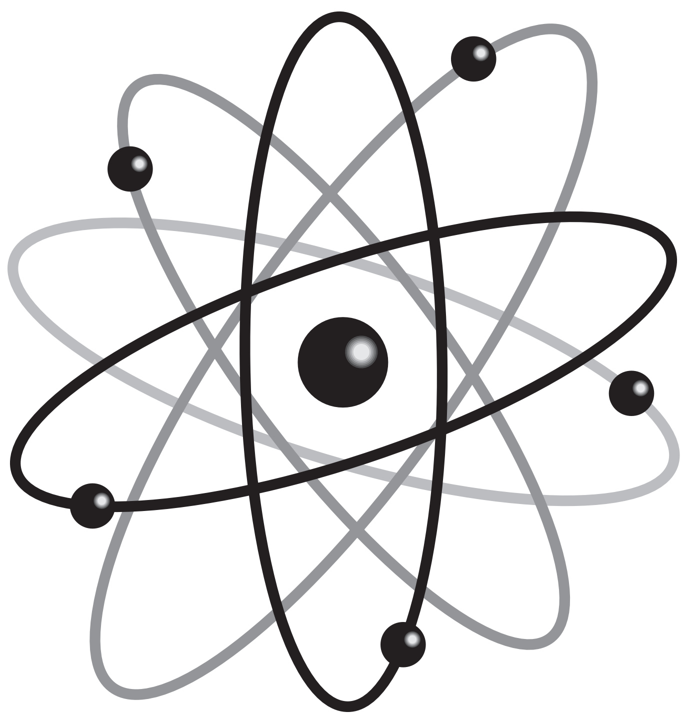
Have students construct, test, and submit an exercise of their own.

References

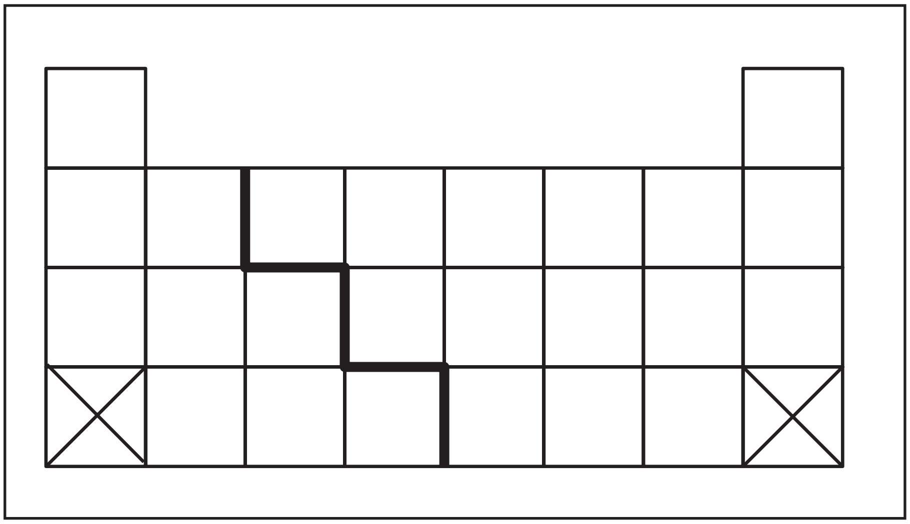
Chemistry (41) 11, Dec. 1968, p. 36.
Mahan, Bruce H. University Chemistry. Reading, Mass. Addison-Wesley, 1969.
"The Periodic Table." *The World of Chemistry*. S. Burlington VT: The Annenberg/CPB Collection, 1990. (video seven in an excellent collection of 26 produced by the University of Maryland and the Educational Film Center).
Puddephatt, R. J. and P. K. Monaghan. *The Periodic Table of the Elements*. Oxford: Clarendon, 1988.
Sisler, Harry H. *Electronic Structure, Properties, and the Periodic Law*. New York: Reinhold, 1963.

PRB

"*Students should not memorize the periodic table but rather be able to use it....*"



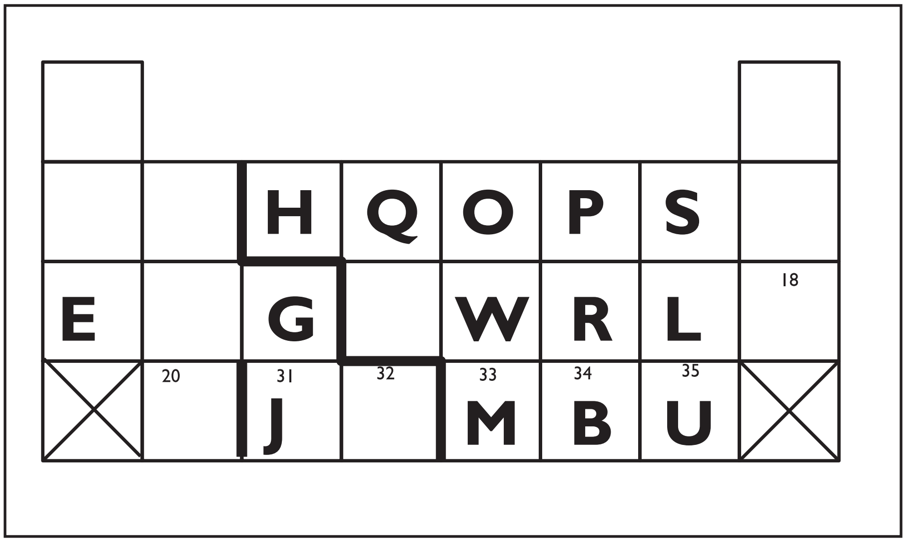
Handout #1
Understanding the Periodic Table



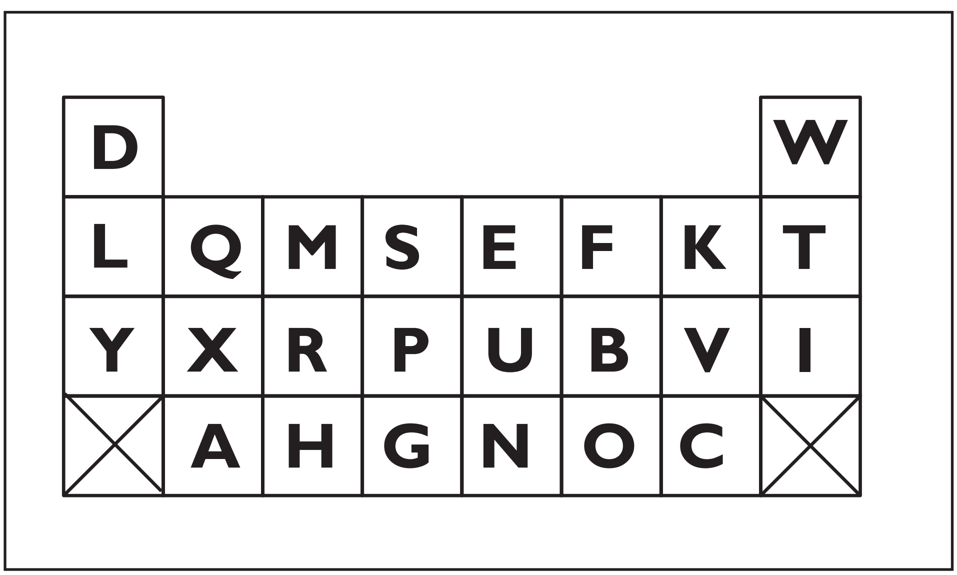
Place only as many as possible.

1. The following groups of elements have similar chemical behavior:
   ULS AFV NIT QCK KDX HJG PRB MOW
2. G has 13 electrons
3. An isotope of M has an atomic weight of 44 with 21 neutrons.
4. H is the lightest in its group.
5. Q's atomic number is six.
6. O is lighter than G.
7. E is the most active metal.
8. R is more active than B.
9. P has a valence of -2 and holds electrons best in its group.
10. S accepts electrons easier than any of the above.
11. L can replace U from a compound.

Key for Handout #1

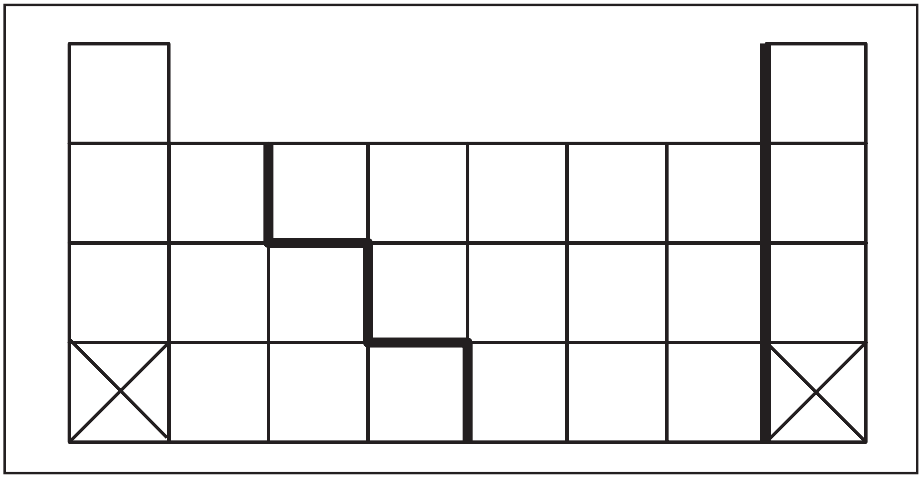


Key for Handout #2.



Handout #2

Understanding the Periodic Table



The elements have been coded. Use the clues to locate them on the short form of the table pictured above.

1. The following elements belong together in groups:
   UNE CKV GPS FOB DLY WIT AQX MRH
2. U has 15 electrons.
3. G has four electrons *in its outer shell.*
4. W, I, and T form no compounds.
5. K is the most active non-metal.
6. C is a liquid; K and V are gases.
7. The atomic number of I is 18.
8. D, E, and F are diatomic gases.
9. D_2F is water.
10. Y is the most active metal shown.
11. R's electron configuration is $1S^2$, $2S^2$, $2P^6$, $3S^2$, $3P^1$.
12. R is more active than M, but less active than H.
13. A is more active than H, R, M, Q, and X.
14. X is heavier than Q.
15. The atomic mass of P is more than S but less than G.
16. O has more neutrons than N.
17. T freezes before W.
18. (Extra clue) K can replace V from compound LV.

Reference: Based on a similar exercise reprinted from the Oregon Science Teacher in Chemistry (41) 11, December 1968, p. 36. Many versions were used with success in teaching high school and college chemistry by Paul R. Boehlke. The exercise focuses on the principles and applications of the table.

Some Common Chemical Substances

Some chemicals for demonstrations and experiments can be purchased in the community. Others will have to be obtained from science supply houses. The use of household chemicals can save money and the trouble of ordering. Furthermore, one can build chemical literacy by encouraging students to read labels and recognize what is in common products. Too often chemicals are thought of as being something foreign and dangerous. All matter is chemical, and the dangers depend on how the chemicals are used. A lesson using a selection of common chemicals which asks students to read the labels and record the purpose of each product would be a valuable activity in increasing this awareness.

Students should always be cautioned against unauthorized experimentation at home. Cautions on labels should always be observed.

Chemical	Common Name	Formula	Source
acetic acid	vinegar (5% solution)	CH_3COOH	grocery
acetyl-salicylic acid	aspirin	$C_6H_4 \cdot COOH \cdot OCOCH_3$	drug
acetone	nail polish remover also sold in cans as acetone	CH_3COCH_3	drug store; hardware; paint store
aluminum	aluminum foil aluminum wire and sheet	Al	grocery store; hardware; building supply
aluminum oxide	emery (emery paper)	Al_2O_3	hardware
aluminum potassium sulfate	alum	$KAl(SO_4)_2 \cdot 12H_2O$	drug store
ammonium carbonate	smelling salts	$(NH_4)_2CO_3$	drug store
ammonium hydroxide	ammonia (ammonia water)	NH_4OH	grocery
ascorbic acid	vitamin C	$C_5H_7O_4COOH$	drug store
boric acid	boric acid	H_3BO_3	drug store
calcium carbonate	chalk	$CaCO_3$	classroom
	marble chips		garden supply
	limestone		garden supply
calcium oxide	quick lime	CaO	hardware
calcium phosphate	superphosphate	$Ca(H_2PO_4)_2$	garden supply
carbon	charcoal	C	grocery
	activated charcoal		pet store
	graphite (powder)		hardware
	graphite (rod)		pencil 'lead'
	diamond		jewelry
carbon dioxide, solid	dry ice	CO_2	refrigeration supply
carbon dioxide, gas	carbon dioxide		mix baking soda & vinegar, Alka-Seltzer
citric acid	sour salt	$C_5H_7O_5COOH$	grocery
copper sulfate	bluestone algicide	$CuSO_4 \cdot 5H_2O$	pool supply
ethylene glycol	antifreeze	$HOCH_2CH_2OH$	auto supply
fructose	fruit & honey sugar	$C_6H_{12}O_6$	grocery—baking
glucose	dextrose	$C_6H_{12}O_6$	drug store
glycerol	glycerin	$C_3H_5(OH)_3$	drug store
gold	gold	Au	jewelry—coins
helium	helium	He	gifts, greeting cards, balloons
hydrocarbon mixture	Vaseline	$C_{18}H_{38}$ through to $C_{22}H_{46}$	drug store
hydrochloric acid	muriatic acid	HCl	hardware
hydrogen peroxide	hydrogen peroxide	H_2O_2	drug store
iodine	Tincture of iodine	I_2	drug store
iron	steel wool or nails	Fe	hardware

Chemical	Common Name	Formula	Source
iron (III) oxide	rust (ferric oxide)	Fe_2O_3	ceramic shop
lactic acid	milk acid	$CH_3COHCOOH$	grocery hardware
lead	lead shot	Pb	hardware
	sinkers		sporting goods
magnesium hydroxide	milk of magnesia	$Mg(OH)_2$	drug store
magnesium silicate	talc, talcum powder	Mg_2O	drug store
	baby powder	several forms are known	
magnesium sulfate	Epsom salt	$MgSO_4{\cdot}7H_2O$	drug store
naphthalene	moth balls	$C_{10}H_6$	hardware
nickel	nickel	Ni	Canadian nickel*
phenol red	phenol red	$C_{19}H_{14}O_5S$	pool supply
phenolphthalein indicator	Ex-Lax (tablets)	$C_{20}H_{14}O_4$	drug store
potassium acid tartrate	cream of tartar	$KHC_4H_4O_6$	grocery
potassium nitrate	saltpeter	KNO_3	drug store
silicon dioxide	sand	SiO_2	garden supply
silver	silver	Ag	coin store
sodium bicarbonate	baking soda	$NaHCO_3$	grocery
sodium chloride	table salt	NaCl	grocery
sodium hydroxide	lye	NaOH	grocery
	caustic soda		hardware
sodium hypochlorite	bleach (5% solution)	NaClO	grocery
	mildew remover		paint store
sodium nitrate	nitrate of soda	$NaNO_3$	garden supply
sodium tetraborate	borax	$Na_2B_4O_7{\cdot}10H_2O$	grocery
stearic acid	candle hardener	$C_{17}H_{35}CO_2H$	hobby or craft shop
sucrose	table sugar from	$C_{12}H_{22}O_{11}$	grocery
	sugar cane or beets		
sulfur	flowers of sulfur	S	drug
	brimstone		hardware
sulfuric acid	battery acid	H_2SO_4	auto store
tannic acid	tannin	$C_{76}H_{52}O_{46}$	drug store, dye/fabric store, photo store
zinc	zinc	Zn	grocery-canning covers
zinc silicate	calamine	$2ZnO{\cdot}SiO_2{\cdot}H_2O$	drug store
Miscellaneous			
strips to test for simple sugar			drug store
acid/base indicator	boil red cabbage leaves in water, save juice		grocery store

*High school chemistry teachers: The periodic chart places nickel next to iron and indicates that this element should have a number of unpaired electrons like iron. Students should be able to predict that those unpaired electrons if subjected to an external magnetic field would spin in the same direction and could generate an opposite magnetic field. Check to see if nickel is attracted by a magnet like iron. Students would not expect this result because of their familiarity with U.S. nickels. Aha, but the U.S. nickel is 75% copper and 25% nickel. Try a Canadian nickel! Canadian nickels are nickel.

References:

Helmprecht, H. L. and L. T. Friedman. *Basic Chemistry for the Life Sciences*. New York: McGraw Hill Book Co., 1977.

Katz, David A. and Thomas O'Brien. Common Chemicals Around the House. *Chemecology.* May/June, 1991, pp 9-10.

Selected Science Resources

Periodicals that students will enjoy

Dragonfly is a new publication for grades 3-6 from the National Science Teachers Association (NSTA), 1201 16th St. N.W., Washington, DC 20036. Students can write for it. *Dragonfly* attempts to involve school and parents. It will also have a presence on the Internet.

National Geographic World is published by The National Geographic Society, P.O. Box 98178, Washington, DC 20078-9801 (elementary).

Ranger Rick's Nature Magazine is published by The National Wildlife Federation, P.O. Box 777, Mt. Morris, IL 61054-0777 (elementary).

Periodicals for teachers

AIMS is published by AIMS (cf. projects below) containing activities for K-9.

The Biology Teacher comes as part of membership in the National Association of Biology Teachers (NABT), 11250 Roger Bacon Drive, #19 Reston, VA 22090-55202 (secondary & college biology teachers).

CHEMECOLOGY is free from the Chemical Manufacturers Association (CMA), 1300 Wilson Boulevard, Arlington, VA 22209. The publication has articles concerning health, safety, and the environment; the occasional student activities are very interesting. CMA is biased to favor industry but is still useful, and the price is right (secondary chemistry and biology).

The Chemical Educator was first published in 1996 on the World Wide Web at http://chedr.idbsu.edu (secondary and college chemistry teachers).

The Physics Teacher is published by the American Association of Physics Teachers (AAPT) for secondary and college physics teachers who join AAPT. The purpose is to strengthen introductory physics teaching. AAPT Member and Subscriber Services Dept., One Physics Ellipse, College Park, MD 20740-3845.

Science Activities: Classroom Projects and Curriculum Ideas is by subscription from Heldref Publications, a division of the nonprofit Helen Dwight Reid Educational Foundation, 1319 18th St., N.W., Washington, DC 20036-1802 (elementary & secondary).

Science and Children is published by the National Science Teachers Association (NSTA), 1201 16th St. N.W., Washington, DC 20036 (elementary) as a possible choice by members of NSTA.

Science Scope is published by the National Science Teachers Association (NSTA), 1201 16th St. N.W., Washington, DC 20036 (middle school, grades 5-9) as a possible choice by members of NSTA.

Science News is a weekly publication that will keep the science teacher up-to-date on the latest discoveries. *Science News,* 1719 N St., NW, Washington, DC 20036. (secondary and college)

The Science Teacher is published by the National Science Teachers Association (NSTA), 1201 16th St. N.W., Washington, DC 20036 (grades 7-12) as a possible choice by members of NSTA.

Sky and Telescope is for those interested in the stars and is available by subscription from Sky Publishing Corp., P.O. Box 9111, Belmont, MA 02178-9111.

General Science Supplies

Send for catalogs. If you are outfitting a lab or purchasing expensive items such as microscopes, ask the supply company for a bid on the items.

Carolina Biological Supply Company, 2700 York Road, Burlington, NC 27215 (1-800-227-1150)

Frey Scientific, 100 Paragon Parkway, P.O. Box 8101, Mansfield, OH 44901-8101 (1-800-225-FREY)

Nasco, 901 Janesville Ave., Fort Atkinson, WI 53538-0901 (1-800-558-9595) also at Nasco, 4825 Stoddard Road, Modesto, CA 95356-9318

Sargent-Welch, P. O. Box 5229, Buffalo Grove, IL 60089-5229 (1-800-SARGENT)

Ward's, P.O. Box 92912, Rochester, NY 14692-9012 (1-800-892-3583 for catalog requests only, 1-800-962-2660 for orders)

Projects

AIMS is the acronym for *Activities Integrating Mathematics and Science*. The focus is on producing curricular materials for grade

K-9. AIMS runs one or two-day workshops and publishes a monthly magazine. AIMS Educational Foundation, P.O. Box 8120, Fresno, CA 93747-8120

GEMS (or LHS GEMS) are science activities published by GEMS—Lawrence Hall of Science, University of California, Berkeley, CA 94720. GEMS runs workshops.

Project WILD is an interdisciplinary, supplementary environmental and conservation education program emphasizing wildlife for K-12. Project WILD, Salina Star Route, Boulder, CO 80302. Project WILD runs workshops.

TIMS (The Integration of Math and Science) are activities that are produced by the University of Illinois—Chicago (UIC) Institute of Math and Science Education, 840 W. Taylor St., Rm 2075, Chicago, IL 60607-7019. UIC offers a course.

TOPS Learning Systems has a free newsletter that contains sample activities. TOPS sells science and math units using common household materials. Prices are economical. TOPS Learning Systems, 10970 S. Mulino Road, Canby, OR 97013 and ask to be put on their mailing list.

Videos

Miller, Pat and Dan Grunewald. *The Freshwater Hydra.* New Ulm, MN: Martin Luther College, 1994. Miller and Grunewald made this video as a class project during a summer freshwater ecology class. The video and lesson are available from the college's Media Center for a five dollar shipping and handling charge. Permission is also granted to WELS educators to make multiple copies and retain them. A teacher's guide is included (grades 5-12). Media Center, Martin Luther College, 1995 Luther Court, New Ulm, MN 56073-3300

Scientific American Frontiers produces several excellent programs each year on covering many different scientific topics. Shows are aired on the Public Broadcasting System (PBS) and are underwritten by GTE. Permission is granted to educators to copy and retain the programs as long as needed (grade level varies with subject). To be placed on the mailing list for the teacher's guides, call Scientific American Frontiers School Program at 800-315-5010, mail to Scientific American Frontiers, 105 Terry Drive, Suite 120, Newtown, PA 18940-3425, or e-mail to safpal@aol.com. A catalog is available from Hawkhill Associates, Inc., 125 E. Gilman St., P.O. Box 1029, Madison, WI 53701-1029 (1-800-422-4295).

The Metric System

The metric system is used in all the sciences and by almost all countries in the world. The units are defined by an international agreement called the System International d'Unites and are commonly called SI units. Students should learn the metric system by building separate mental concepts of the commonly used units, not by awkward conversion exercises. They should not convert metric units to English units unless it is required by the nature of a particular activity.

measurement	units	abbreviation	definition
distance	meter	m	One meter is the distance that light will travel in free space in 1/299,792,458 seconds
mass (weight on Earth)	gram	g	mass of a cubic centimeter of water
volume	liter (litre)	l	1000 cubic centimeters
time	second	s ("sec" is still widely used)	
	minute	min	
	hour	h	
	year	yr	
chemical amount	mole	mol	6.022×10^{23} molecules
chemical concentration	molarity	M	moles/liter
	normal	N	equivalents/liter
temperature	degrees Celsius	°C	0 °C = 273.15 K
	kelvin	K	
electrical current	ampere	(amps) A	
electrical potential	volt	V	
radioactivity	curie	Ci	3.7×10^{10} disintegrations per second
energy	calorie	cal	
	joule	J	
electrical conductance	siemen	S	$ohms^{-10}$ (inverse of resistance)

Common SI Prefixes and Abbreviations

Prefix	Abbreviation	Definition (value by which unit is multiplied)
nano	n	10^{-9}
micro	u	10^{-6}
milli	m	10^{-3}
centi*	c	10^{-2}
kilo	k	10^{3}
mega	M	10^{6}
giga	G	10^{9}

* SI recommends using prefixes that are multiples of 10^{-3} and 10^{3}. Other prefixes are acceptable under certain conditions, but not recommended. "Centi" is in common usage, such as in "centimeter."