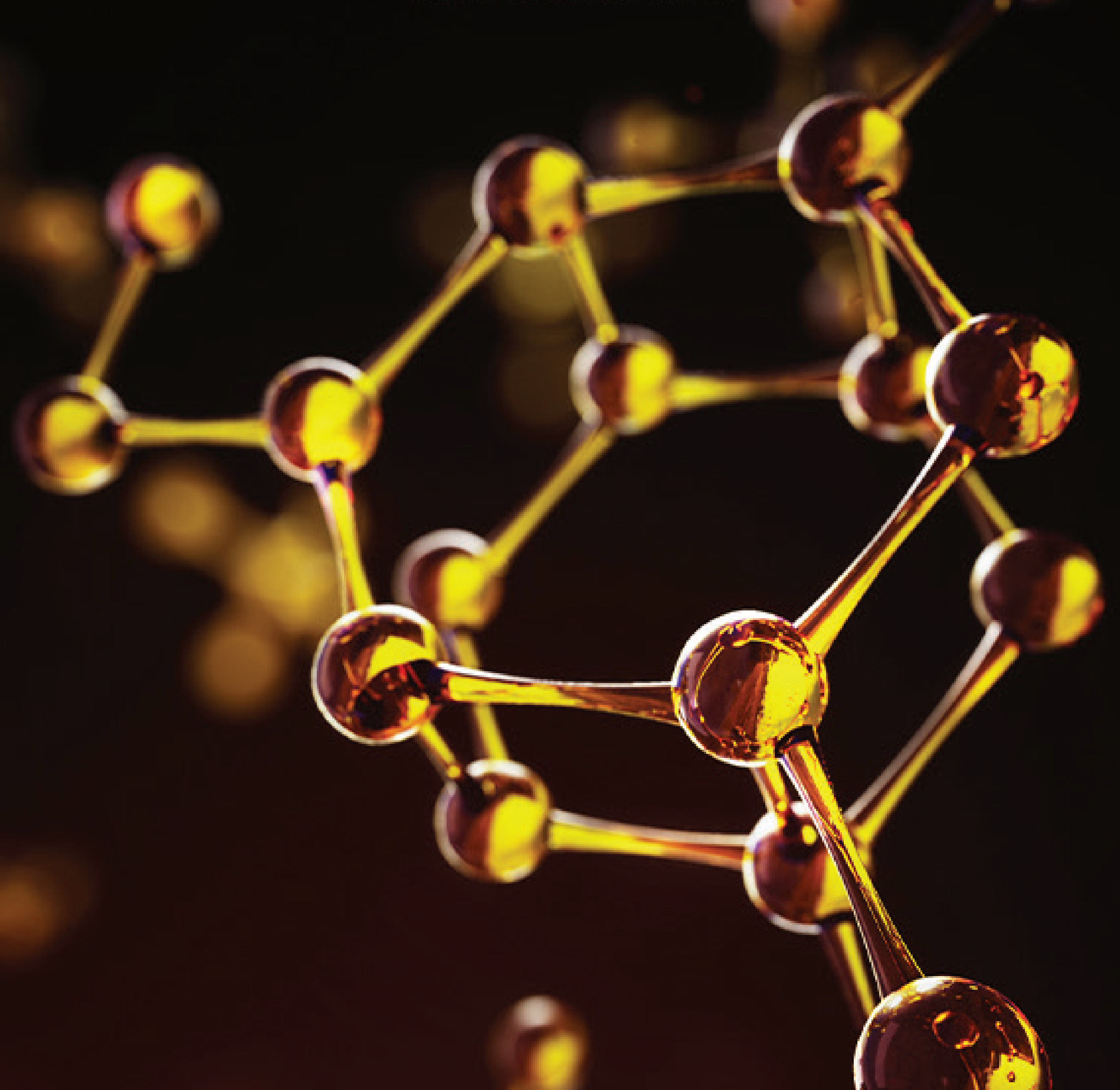
WESTERN MICHIGAN UNIVERSITY

THE MALLINSON INSTITUTE FOR SCIENCE EDUCATION

CHEM 2800 COURSE PACK



CHEM 2800

Laboratories pose a risk of injury or illness because of the physical and chemical hazards present in them. This risk can be lowered substantially or completely eliminated by following these general safety rules:

- Follow your instructor's directions at all times;
- Know the types of hazards that the lab work involves;
- Conduct yourself in a responsible manner at all times in the laboratory;
- Protect your eyes, face, hands, feet, and body;
- Never perform unauthorized experiments or work without an instructor present;
- Never bring food or drinks into the lab;
- Never apply cosmetics (lip gloss, etc.) while in the lab; and
- Abide by the additional rules listed below.

PREPARE FOR LABORATORY WORK

1. Study laboratory procedures prior to class and understand the types of hazards you may encounter.
2. Review the safety information for the chemicals used in the lab (MSDS are available in the lab or online).
3. Keep your lab bench organized and free of apparel, books, and other clutter.
4. Know your exit routes and how to use the safety shower, eye wash, fire blanket, and first aid kit.
5. Put away all distractions such as cell phones and laptop computers.

DRESS FOR LABORATORY WORK

1. Open-toe shoes, sandals, or other footwear that exposes skin of the foot are **NOT** allowed at any time.
2. You must wear appropriate attire while in the lab. Clothing prevents chemical contact with your skin; therefore, low cut tops, bare mid-riffs, above-the-knee shorts and skirts are **NOT** permitted.
3. Avoid wearing overly loose clothing (i.e. long draping sleeves, long fringe) when working in the lab.
4. Tie back long hair when working with chemicals, heat, or mechanical equipment.

Don't risk it! You will be asked to leave the lab if you do not have proper footwear and clothing!!

AVOID CONTACT WITH CHEMICALS

1. Never taste or touch chemicals. Do not "sniff" chemicals unless directed to do so by your instructor.
2. Eye protection must be worn by all persons in the room at all times that anyone is working with or handling chemicals, glassware, or other laboratory apparatus or equipment. Prescription eyewear alone is not acceptable.
3. Wear gloves when contact with chemicals may occur.
4. Wear a lab coat or apron when instructed to do so.
6. Take extra care when handling hazardous chemicals.

Remove your lab coat (or apron) and gloves before leaving the lab so you don't spread contaminants.

AVOID HAZARDS

1. Keep flammable chemicals away from flames (i.e. Bunsen burners).
2. Use caution when handling hot glassware. Use thermal gloves or tongs to move hot items.
3. Turn off burners and hot plates when not in use.
4. When heating substances, keep the opening pointed away from people.
5. Take extra care when handling sharp items such as scalpels, lancets, or other cutting implements.
6. Use test tube racks to prevent rolling and breakage.
7. Keep caps on chemical bottles. Never switch caps. Don't let the open edge of the cap contact any surface.

CLEAN UP AT THE END OF LAB

1. Always follow your instructor's directions regarding the proper disposal of chemicals. *Never* pour chemicals down the drain or put in the trash unless your instructor tells you to do so.
2. Never return unused chemicals to its container. Only take as much chemical as you need to avoid excessive waste.
3. Wash hands thoroughly following experiments AND before leaving the lab.
4. Leave laboratory bench clean and neat. Return all equipment to the location you found them.

IN CASE OF ACCIDENT

1. Report all accidents and spills (no matter how minor) to your instructor immediately.
2. Place broken glass in designated boxes. Never pick up broken pieces with your hands. Use a dust pan & broom.
3. Wash all chemicals from your skin immediately using plenty of running water.
4. If chemicals get in your eyes, wash them for at least 15 minutes with an eye wash.
5. If a large chemical splash to your body occurs, use the safety shower immediately.
6. Treat minor cuts or burns with the first aid kit. Injuries that cannot be easily treated with the contents of the first aid kit are medical emergencies!

Periodic Table

hydrogen 1 H 1.0079																		helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122												boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305												aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078		scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62		yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	89-102 **	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	ununnilium 110 Uun [271]	unununium 111 Uuu [272]	ununbium 112 Uub [277]		ununquadium 114 Uuq [289]				

*Lanthanide series	lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
**Actinide series	actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

In a sense CHEM 2800 is more of a physical science course, than only a chemistry course. You will be involved in concept-based inquiry. You will be involved in "making sense" of observations. You will be involved in building models. You will be involved in constructing scientific knowledge and then reflecting on it. You will be involved in the process of science as well as becoming familiar with the body of knowledge of science.

Richard Feynman, Nobel Laureate of Physics, once said that if only one sentence, one piece of knowledge, could be handed down to future generations, the most important sentence should be...All matter is composed of atoms. The importance of that idea forms the theme of CHEM 2800. The theme of this course, the idea that ties the course together is the particle model of matter. So most of the activities will (hopefully) help you arrive at this model and make it believable to you.

You will start out doing activities involving gases, then move on to studying liquids and solids. Along the way you should develop understanding of the concepts of heat and temperature and thermal energy. And you should begin to understand how the observed phenomena can be understood in terms of a particle model of matter and in terms of the forces that act between the particles.

Then you will be introduced to the electrostatic force, the force that arises between objects that have charge. This force is similar to, but distinctly different from, the gravitational force that arises between objects that have mass. The electrostatic force is the important fundamental force that exists between the particles (or atoms) in gases, liquids, and solids found in nature.

It is impossible (at least for the folks developing this course) to think of activities that can be done in this class, which will lead you to the basic ideas of atomic structure. The activities are too tough and require too much expensive equipment! But these ideas are crucial and important (see the Feynman statement above!) So...a different approach will be used. The historical development of the ideas of atomic structure will be presented, culminating in the development by Niels Bohr of a simple model of the hydrogen atom.

Armed with this simple "Bohr model" one can begin to understand the structure of more complicated atoms, and that will be your task- with the help of your instructor. This will lead to insights into the structure of molecules and, finally, how atoms and molecules interact with one another. The realm of chemistry will be opened to your understanding!

We hope you will have an enjoyable and fruitful semester.

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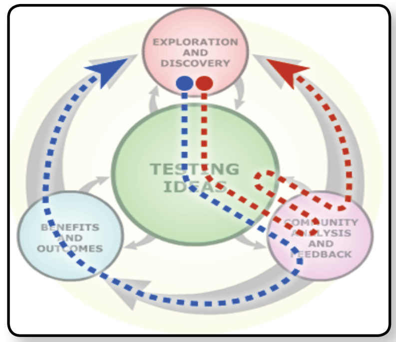

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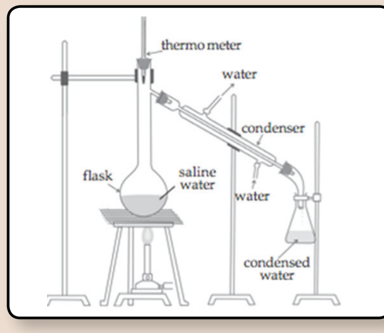

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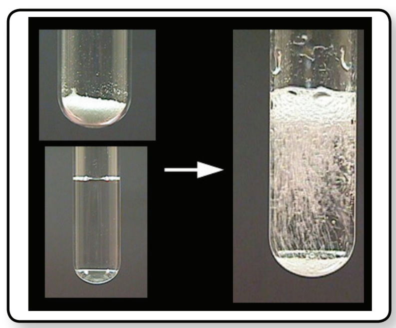

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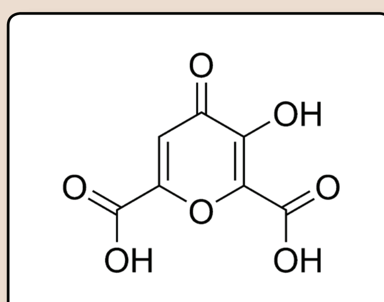


UNIT I
UNIT II
UNIT III
UNIT IV

1. SWBAT define chemistry and why it is important to learn about it.
2. SWBAT apply NOS to chemistry concepts
3. SWBAT describe the big ideas for the course that will be covered.
4. SWBAT utilize basic laboratory equipment used in chemistry investigations.
5. SWBAT recall and apply concepts of volume, area, mass, and weight.
6. SWBAT recognize metric units of measure.
7. SWBAT convert metric units of measure.
8. SWBAT calculate answers utilizing appropriate significant figures.
9. SWBAT describe matter at both micro and macro levels.
10. SWBAT differentiate between chemical and physical properties of matter.
11. SWBAT identify the three phases of matter and provide characteristics of each.
12. SWBAT recognize the particulate nature of matter.
13. SWBAT state and apply basic gas laws.

Nature of Science (NOS) Objectives:

1. SWBAT define the following terms: observations, inference, experiment, theory, law, tentative, subjective, objective, empirical, creative, theory-laden, hypothesis and model.
2. SWBAT identify a given scientific scenario as using observation, experimentation and/or though experiments.
3. SWBAT provide an example of an in class activity that exemplified tentativity, subjectivity, empirical NOS, and creativity and support their claim with evidence.
4. SWBAT compare and contrast the concepts of theory, law and hypothesis.

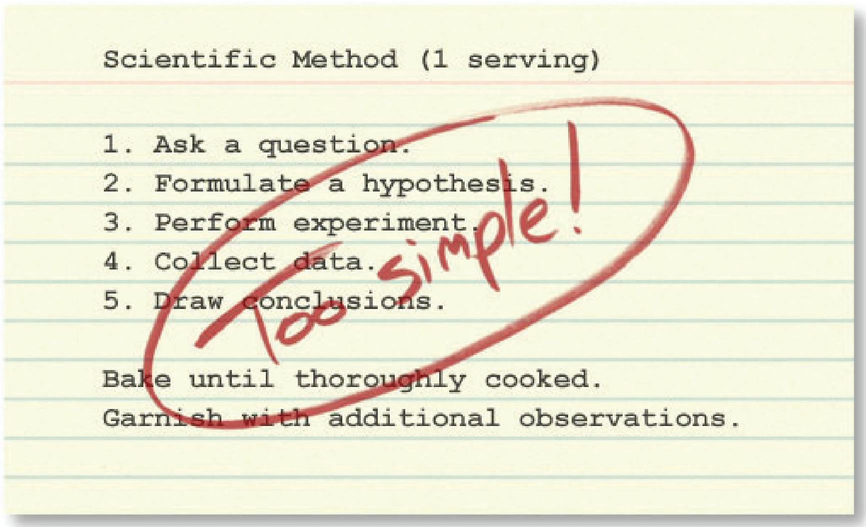
NOTES:

Big Ideas in Chemistry	Important Topics within These Ideas	MTTC	CHEM 2800
Conservation of matter and energy	-SWBAT explain that atoms are not destroyed in chemical reactions; they are rearranged -SWBAT distinguish between forms of energy; energy changes in chemical reactions -SWBAT solve stoichiometry problems and balance chemical reactions to support that mass is conserved	Physical Science: 016, 017, 018, 019	Unit III
Behavior and properties of matter	-SWBAT examine the periodicity of the periodic table as the master organizer of chemistry -SWBAT explore and discriminate between different gas laws -SWBAT distinguish among elements, compounds, and mixtures -SWBAT model and explain what happens during chemical bonding -SWBAT apply knowledge of intermolecular forces to chemical bonding	Physical Science: 016, 017	Unit I and Unit II
Particulate nature of matter	-SWBAT explain molecular behavior using the Kinetic Molecular Theory -SWBAT model, diagram, and explain the structure of atoms, ions, and molecules	Physical Science: 016, 017	Unit II and Unit IV
Equilibrium and driving forces	-SWBAT investigate variables in reaction rates -SWBAT explore acid-base reactions -SWBAT analyze concepts of thermodynamics	Physical Science: 016, 017	Unit III and Unit IV

Thermodynamics	-SWBAT discriminate between different forms of energy -SWBAT show how energy can move or transform from one system to another but that total energy is conserved -SWBAT describe modes of heat transfer	Integrated Science: 021	Unit IV

– **adapted from ACS Guidelines and Recommendations for the Teaching of High School Chemistry: Spring 2012**
www.acs.org/education

The Scientific Method is traditionally presented in the first chapter of science textbooks as a simple recipe for performing scientific investigations. Though many useful points are embodied in this method, it can easily be misinterpreted as linear and "cookbook": pull a problem off the shelf, throw in an observation, mix in a few questions, sprinkle on a hypothesis, put the whole mixture into a 350° experiment—and *voila*, 50 minutes later you'll be pulling a conclusion out of the oven! That might work if science were like Hamburger Helper®, but science is complex and cannot be reduced to a single, prepackaged recipe.



The linear, stepwise representation of the process of science is simplified, but it does get at least one thing right. It captures the core logic of science: testing ideas with evidence. However, this version of the scientific method is so simplified and rigid that it fails to accurately portray how real science works. It more accurately describes how science is summarized *after the fact*—in textbooks and journal articles—than how science is actually done.

The simplified, linear scientific method implies that scientific studies follow an unvarying, linear recipe.

But in reality, in their work, scientists engage in many different activities in many different sequences. Scientific investigations often involve repeating the same steps many times to account for new information and ideas.

The simplified, linear scientific method implies that science is done by individual scientists working through these steps in isolation.

But in reality, science depends on interactions within the scientific community. Different parts of the process of science may be carried out by different people at different times.

The simplified, linear scientific method implies that science has little room for creativity.

But in reality, the process of science is exciting, dynamic, and unpredictable. Science relies on creative people thinking outside the box!

The simplified, linear scientific method implies that science concludes.

But in reality, scientific conclusions are always revisable if warranted by the evidence. Scientific investigations are often ongoing, raising new questions even as old ones are answered.

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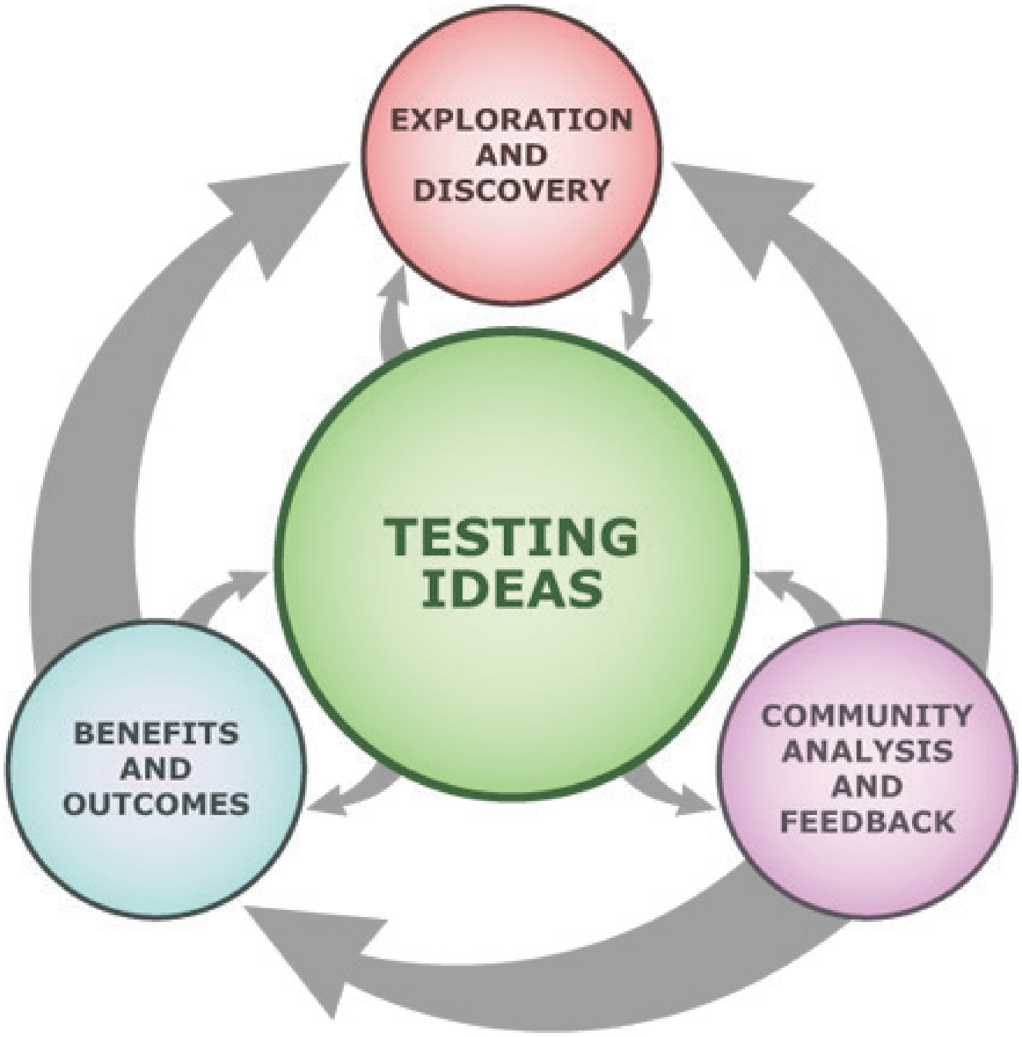
The process of science, as represented here, is the opposite of "cookbook" (to see the full complexity of the process, roll your mouse over each element). In contrast to the linear steps of the simplified scientific method, this process is non-linear:



- **The process of science is iterative.**
  Science circles back on itself so that useful ideas are built upon and used to learn even more about the natural world. This often means that successive investigations of a topic lead back to the same question, but at deeper and deeper levels. Let's begin with the basic question of how biological inheritance works. In the mid-1800s, Gregor Mendel showed that inheritance is particulate—that information is passed along in discrete packets that cannot be diluted. In the early 1900s, Walter Sutton and Theodor Boveri (among others) helped show that those particles of inheritance, today known as genes, were located on chromosomes. Experiments by Frederick Griffith, Oswald Avery, and many others soon elaborated on this understanding by showing that it was the DNA in chromosomes which carries genetic information. And then in 1953, James Watson and Francis Crick, again aided by the work of many others, provided an even more detailed understanding of inheritance by outlining the molecular structure of DNA. Still later in the 1960s, Marshall Nirenberg, Heinrich Matthaei, and others built upon this work to unravel

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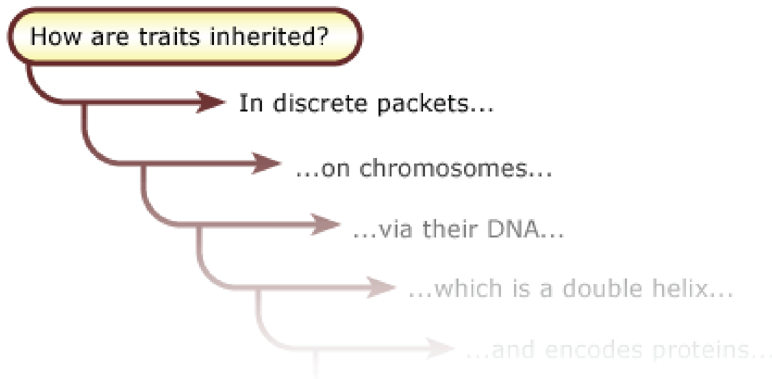
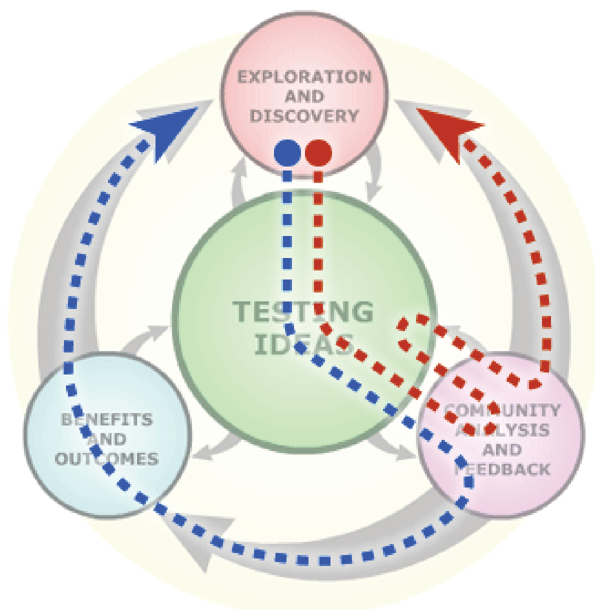
the molecular code that allows DNA to encode proteins. And it doesn't stop there. Biologists have continued to deepen and extend our understanding of genes, how they are controlled, how patterns of control themselves are inherited, and how they produce the physical traits that pass from generation to generation.

Science investigates questions at deeper and deeper levels:



- **The process of science is not predetermined.**
  Any point in the process leads to many possible next steps, and where that next step leads could be a surprise. For example, instead of leading to a conclusion about tectonic movement, testing an idea about plate tectonics could lead to an observation of an unexpected rock layer. And that rock layer could trigger an interest in marine extinctions, which could spark a question about the dinosaur extinction—which might take the investigator off in an entirely new direction.



At first this process might seem overwhelming. Even within the scope of a single investigation, science may involve many different people engaged in all sorts of different activities in different orders and at different points in time—it is simply much more dynamic, flexible, unpredictable, and rich than many textbooks represent it as. But don't panic! The scientific process may be complex, but the details are less important than the big picture …

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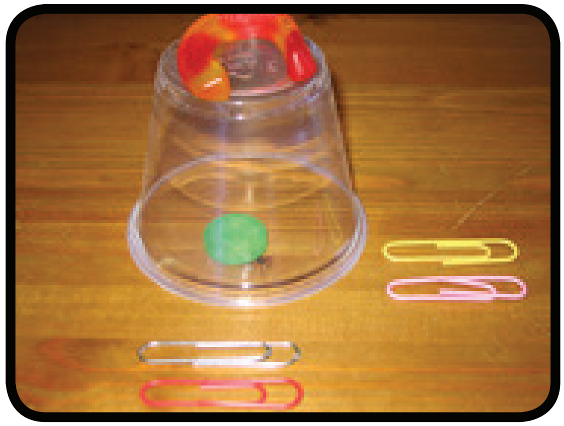

Fred has been spending his summer boating on the great lakes. But he's not too bright (after all, the brains of worms are pretty small): He's never learned how to swim and he never wears his life preserver. The worst has happened! His boat has capsized and he is stuck! Fortunately, his life preserver is in the boat, but unfortunately, he does not know how to reach it without falling off and drowning.

Problem:
How can you and your group save Fred using only 4 paper clips. You may not touch Fred, the boat, or the life preserver directly with your hands.

Materials:
- Gummy Worm
- Gummy life preserver
- 1 Plastic Cup
- 4 Paper Clips

Procedures:
1. Work with your group and "Save Fred".

2. Follow the rules:
    <u>Fred, the boat, the life preserver can be touched only with the paper clips. NO HANDS.</u>

3. Develop a plan to "Save Fred"

Draw a picture of your plan:	What steps do you need to follow?
What were some challenges your group encountered?	
How did your group over come challenges?	