SCIENCE
Teaching in DYS Schools

An Instructional Guide for Educators in the Massachusetts Department of Youth Services

September 2007
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## INTRODUCTION
Beliefs, commitments, and teaching practices for the education of youth in DYS custody are shaped by our understandings of DYS students and settings. These in turn determine what professional development and training teachers will need to provide effective instruction to DYS learners. Reviewing philosophy, principles, and mission provides a birds-eye view of educational programming for young people in DYS custody, with explicit safety guidelines included for teachers’ ease of reference.

## RESPONSIVE SCIENCE TEACHING
This chapter offers fundamental information about responsive teaching, including ideas, strategies, and additional resources that help teachers build on students’ prior experiences and understandings, create caring learning environments, facilitate active student participation, and implement routine classroom practices that feature carefully planned transitions and regular displays of each lesson’s language and content objectives.

## FRAMING CURRICULUM AND INSTRUCTION
We begin by defining the terms —curriculum, instruction, framework, strands, standards, and assessments—that create the foundation for standards-based teaching. Our goal is to help teachers organize and plan differentiated instruction that responds to students’ backgrounds, interests, and prior knowledge.

## STRANDS AND EMPHASIZED STANDARDS
Given the extraordinary diversity and mobility in DYS classrooms, how can teachers align their instruction with the Massachusetts Curriculum Framework? Balancing consistency with flexibility is key. Teachers address the components of science education across all settings by teaching short mini-units and Problems of the Day that emphasize the most crucial standards and strategies in each of the curriculum strands.

## CURRICULUM RESOURCES FOR DYS TEACHING
Guidelines and exemplars to help teachers develop high-quality curriculum and instruction based on explicit learning objectives. Resources include Scope and Sequence, standards-based grids for all emphasized standards (what students should Know, Understand, and be able to Do), a 7-day genetics mini-unit in Biology, a fully-developed lesson within that mini-unit, and fully-articulated Problems of the Day for Biology, Chemistry, and Physics.

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## ADDITIONAL RESOURCES
A compendium of valuable print and web-based resources for eliminating misconceptions and teaching Biology, Chemistry, and Physics using Scientific Inquiry Skills.

## ASSESSMENT
Definitions, resources, and strategies for balanced assessment using Bloom’s Taxonomy, student work, rubrics, and other techniques to analyze and measure students’ progress and attainment of learning objectives.
This Science Instructional Guide is the third in a series of instructional guides prepared by the Commonwealth Corporation for DYS teachers. The guides focus on major content areas in DYS—English Language Arts, Math, Science, and Social Studies. These instructional guides are aligned with the extensive program of professional development, training, and coaching provided in partnership with the Hampshire Educational Collaborative. All of the DYS Instructional Guides are aligned with both the Massachusetts Curriculum Frameworks and the goals and principles of the DYS education system, and share the same general outline and instructions for use.

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**DYS EDUCATION MISSION**

DYS seeks to provide a comprehensive high quality educational system that meets the needs, experiences, and goals of our youth. Through collaboration with local schools, community-based organizations, families, and other resources, DYS Education seeks to provide an individualized student plan that focuses on literacy and numeracy skills, education and employment training opportunities, and transition to the community and the workforce.

**DYS STUDENT POPULATION**

The DYS population is demographically diverse by race, ethnicity, language, culture, age, and economics, and educationally diverse with respect to their background knowledge, interests, aspirations, learning styles, multiple intelligences, social-emotional strengths and challenges, and personal histories. As teachers, we need to begin with a fundamental recognition that our students come from a range of cultural and economic backgrounds that are often very different than those of their teachers.

When compared with the rest of the state’s population, the young people in DYS custody reflect disproportionately high percentages of youth of color (African-American and Latino), youth for whom English is a second language, and students with learning disabilities. Many of our students have special needs that may or may not have been recognized and attended to in their previous educational experiences. The DYS committed caseload decreased 9% between 1996-2006; the system currently serves approximately 5,600 students per year, with roughly 1,900 students in residential and community programs at any given time. DYS students in the committed population are 43% white, 26% African American, 24% Latino, 3% Asian, and 4% “other.” Youth are between 10 and 19 years old, with an average age of approximately 17 years.

Some of our youth have done well in school and will use our classes to build and expand their success as learners. Others have not done well in school, and many are significantly behind their peers in science or other academic areas. Many of our students come with a history of failure, low expectations, and criticism in traditional schools, and find that they learn best when actively engaged and able to make connections to their own real-world experiences and contexts. These factors and statistics do not begin to tell the stories of who our students really are, but they do illuminate some of the differences between the backgrounds of teachers and students in DYS settings.

We have unique opportunities in DYS programs to build authentic teaching and learning practices. When educators are attuned to the attributes their students bring with them, and sensitive to issues and opportunities related to diversity, we are better able to foster environments where differences are valued as useful tools for teaching, learning, and engaging all students. By examining our own backgrounds, affirming our students by building on their strengths, interests and enthusiasms, reinforcing their efforts, and recognizing their growth, teachers can impact student learning even in a short period of time. As DYS educators, we have the chance to offer our students successful experiences—often for the first time in their lives!

**DYS EDUCATION PROGRAMS**

Every day, the Department of Youth Services provides educational services to more than 1,900 young people in 58 sites across Massachusetts. In addition, DYS operates 32 day programs to serve youth transitioning back into the community and residing with parents, guardians, or in independent living programs. All DYS education and services focus on preparing youth to re-integrate successfully into their communities and make successful transitions to public schools, alternative education programs, GED preparation, post-secondary education, job skills training, or employment. Programs operate under contract with DYS, and are run by numerous vendors and community-based organizations.
The DYS facilities in Massachusetts include:

- **Detention sites**
  for youth in the pre-commitment stage

- **Assessment sites**
  for youth committed to DYS and awaiting determination of placement

- **Treatment sites**
  short-term and long-term secure treatment programs for young people

DYS education programs include:

- Academic services, GED preparation, vocational education, life skills programming, and/or post-secondary education services;

- Education Liaisons who provide educational guidance to DYS students and programs and support the re-entry of students into local schools;

- Special education services, provided through the Massachusetts Department of Education’s Special Education in Institutional Settings’ (SEIS) organization, formerly known as “Educational Services in Institutional Settings” (ESIS);

- Title I supplemental services, provided through federal entitlement funds;

- Vocational/work programs including extended day, job training, and employment, provided through partnerships with vocational-technical high schools and WIA (Workforce Investment Act) youth programs.

While size, type, location, security levels, and other factors vary a great deal among the 58 DYS facilities across the Commonwealth, all DYS settings are united by shared principles, guidelines, professional development, curricular materials, and coaching. Educational programming operates on a 12-month school year, with a minimum of 27.5 hours of instructional services per week. DYS educational services strive to meet all Massachusetts education standards, policies and procedures, including requirements for time and learning and highly-qualified educator certification.

**ESSENTIAL QUESTION**

*Given what we know about the young people we teach and the settings in which we teach them, what should DYS educators be doing instructionally?*

The nature of detention, assessment and treatment for youth in DYS custody contributes to extremely high levels of student mobility. High mobility, as well as students’ diverse ages, varied academic skills, and the large numbers of students with special needs, pose unique challenges and opportunities in all DYS educational programs. We have, therefore, developed a set of teaching practices, guiding beliefs, and professional development goals that are shared among all DYS settings. These components, which are briefly summarized on the following page, are drawn from extensive research on successful practices for youth who are placed at-risk by social, economic, or environmental stressors.
EFFECTIVE TEACHING PRACTICES FOR YOUTH IN DYS SETTINGS

**Learning Objectives** for each lesson are developed with an understanding of the diverse needs of the learners, and are in alignment with the state curriculum frameworks’ standards. The objectives are clearly and visibly shared with students.

High-quality curriculum and instruction are built around real-life situations that are culturally responsive to the diverse youth in our programs.

**Differences** in students’ learning profiles, interests, cultural and linguistic backgrounds, and prior knowledge and experiences are used to adjust curriculum and instruction so that it addresses learners’ needs and increases their interest and engagement with the information.

A can-do attitude, driven by high expectations, is established and maintained in every classroom.

Instruction is planned and delivered to build on students' strengths, interests, and prior knowledge, and to reinforce their efforts through encouragement, praise and motivation.

Teachers strive to be “the guide on the side,” not “the sage on the stage,” by treating students as active learners, not as passive recipients of instruction.

Instruction is focused on key themes that allow the students to see connections across topics, and reinforce understanding by involving students in meaningful and authentic tasks.

Literacy and numeracy are integrated into all lessons, with emphasis on increased vocabulary, enhanced comprehension and improved qualitative skills.

Teachers use a variety of instructional strategies and resources—particularly hands-on, project-oriented, cooperative, visual, and contextual learning—to engage the diverse student population.

Instruction is planned with the final assessment in mind. Different levels and types of questions are used throughout the learning process to assess on-going knowledge and understanding, and instruction is adjusted regularly to prepare students for the formal unit assessment.

DYS PROFESSIONAL DEVELOPMENT GUIDING BELIEFS

The Department of Youth Services provides high-quality, standards-based professional development for DYS Education staff in each critical role: teacher, teaching coordinator, education liaison, and area education coordinator. A professional development system—common release days, opportunities for professional development in regional trainings, coaching, and courses—supports staff in learning about and implementing practices effective in juvenile justice education. DYS Professional Development is standards based and will be driven by an increasing focus on student work, use of mathematics, reading, and writing across all content areas, effective teaching in a culturally and linguistically diverse student population, use of the arts and technology to teach to the standards, and development of teacher leadership.
DYS PROFESSIONAL DEVELOPMENT GOALS

Standards-Based Curriculum
Assist teachers in the implementation of DYS standards-based curriculum, as measured by learning objectives connected to the state curriculum frameworks and the effective use of the DYS Instructional Guides, instructional resources, and multiple means of assessment.

Literacy & Numeracy
Promote literacy and numeracy, as measured by the teacher’s demonstration and assessment of student listening, speaking, reading, and writing across all content areas, in all trainings, resources, and curriculum.

Differentiated Instruction
Prepare teachers to differentiate using standards-based instructional practices suitable to a juvenile justice system, as measured by the teacher’s development and demonstration of curriculum, instruction, and assessment appropriate to students’ prior knowledge, interests, and learning styles and needs.

KEY ELEMENTS

Instruction will explicitly include:

- Specific goals / learning objectives
- Links to students’ prior knowledge and understanding
- Daily routines and practices that honor and incorporate students’ social and academic needs and assets
- Varied instructional strategies (such as visual, auditory, oral, hands-on, technology)
- Multiple means for student engagement: listening, speaking, reading, writing, and doing
- Mutual respect and contextual learning
- Ongoing demonstration of student learning and understanding as evidenced by pre- and post-assessments
Science teachers in DYS settings face unique challenges in providing engaging classroom activities and laboratories not only under restrictive circumstances, but also within buildings that were not originally designed or constructed for these purposes.

It is essential for the safety and protection of both students and staff that DYS priorities be balanced with the legally required science safety practices that have been outlined by the Massachusetts Department of Education. The mandated incorporation of these requirements into our science classrooms provides an opportunity for creative approaches to teaching subject matter. At the same time, attention to safety, security, and legal requirements heightens the need for teachers to increase their knowledge and awareness of the benefits and risks involved in each science lesson.

Because each program is different, each Program Director, in collaboration with the Teaching Coordinator, is responsible for crafting program-specific science safety guidelines that adhere to DYS policies. It is the responsibility of the teacher, however, to help inform these decisions. Every DYS teacher—including those working in facilities or programs operated by providers under contract with DYS—is responsible for obtaining approval from the Program Director prior to using any lab materials, tools, and chemicals that might be in question.

Teachers should communicate to the Program Director the following:

- **Purpose** of the science laboratory or activity
- **Potential benefits**, as well as the **potential harm**, of using particular materials, tools, and chemical substances
- **Precautions** taken by teachers, students, and other staff to **avoid accidents or injury**
- **Consequences** or **strategies** for handling possible misuse of science materials and resources

Teachers must also consider how safety rules and guidelines will be communicated to their students. **Science safety rules should be clearly posted in each classroom.** Teachers can also refer to the appendix of the Massachusetts Curriculum Framework High School Science Standards for resources on student safety contracts and how they can be used in the classroom.

Additionally, please note that **wearing protective goggles in school laboratories is required by Massachusetts law**, which explicitly requires that teachers, pupils, and visitors must “wear an industrial quality eye protective device, approved by the department of public safety.” It is critically important for teachers to make students aware of the hazards of working with chemicals and open flame in the laboratory and other settings, and to be sure they wear goggles to protect their eyes.
The **Department of Youth Services Official Contraband Policy** expressly prohibits contraband, weapons and **drugs**, or any other items that clients or visitors may use to hurt themselves or others, or use to engage in illegal or prohibited activities, from being brought into any DYS facility or program; this includes facilities or programs operated by providers under contract with DYS. Contraband is defined as: “articles or objects...that locations deem to be inappropriate, or a threat to the safety and security of the clients, staff and the location.”

With this definition in mind, the contraband policy also states that:

“A Program and Facility Manager **may authorize**, for specific reasons and for specific occasions only, that **something that ordinarily is considered contraband will not be considered contraband**, or that something that ordinarily is not considered contraband will be considered contraband.”

In considering whether otherwise contraband materials should be considered usable for science instruction, the four considerations listed opposite (purpose, potential benefits and potential harm, precautions to avoid accidents or injury, and specific consequences or strategies to avoid misuse) must be communicated to the Program Director. Additionally, such **materials must be inaccessible and locked at all times** that they are not used for instruction, and a designee of the Program or Facility Manager must explicitly be charged with responsibility for the key. This, too, must be communicated with the Program Director at each facility.

**Legal information and guidance** about safety and security in the context of science instruction can be found in Appendix IV of the Science and Technology/Engineering Curriculum Framework. All DYS teachers have a copy of this framework, which can also be downloaded as a PDF from:

http://www.doe.mass.edu/frameworks/scitech/1006.pdf

When using, storing, or disposing of any chemical substance (including household items), **DYS teachers should refer to the guidelines outlined in Material Safety Data Sheets** (or MSDS) for each substance, and keep a copy of an applicable MSDS on the premises. The following websites provide important information on Material Safety Data Sheets:

http://www.flinnsci.com/search_MSDS.asp

http://www.ilpi.com/msds/faq/index.html

Additional safety resources can be found at the following websites:


RESPONSIVE SCIENCE TEACHING
OVERVIEW OF RESPONSIVE SCIENCE TEACHING

This chapter has been created as a resource for DYS science educators and others engaged in the process of teaching youth in the care and treatment of the Massachusetts Department of Youth Services. To familiarize teachers with key ideas and strategies for responsive teaching, we have emphasized important components and connections that support student success. Each of these elements is necessary, and none should stand alone; their strength is that they are all interconnected.

- Designing lessons based on students’ prior experiences
- Creating a caring learning environment
- Facilitating active student participation
- Attention to students’ prior experiences and understandings
- Routine classroom practices with carefully planned transitions
- Daily display of each lesson’s language and content objectives
- Routine display of how students will be assessed

In DYS settings, the student population represents a wide age span, varied learning styles, multiple intelligences, and diverse cultural and educational backgrounds and learning strengths. The amount of time for which students are in the care and treatment of the Massachusetts Department of Youth Services can range from one day to multiple years, and it is not unusual for students to move with frequency from one DYS facility to another, or in and out and then back into DYS facilities. This movement results in limited opportunities for students to engage in sustained study with a cohort of peers and build relationships with teachers. Furthermore, ensuring a safe learning environment within a DYS facility is both a priority and a necessity. All of these factors and variables impact teaching, requiring that we teach science in responsive ways that are flexible, dynamic, and fluid.

As teachers in DYS settings, we use standards-based curricula, differentiate instruction, and focus on literacy and numeracy in all of our work. To do this in culturally responsive ways requires that we approach our work by:

1. Knowing our students;
2. Developing a lesson plan that we will believe will work for our students to learn;
3. Listening carefully to our students’ responses to the lesson; and
4. Using this data to inform our next steps and make modifications that are needed.

Developing a responsive plan is similar to the model of scientific inquiry. We make observations, raise questions, and formulate and test hypotheses that inform our next steps and enable us to make further modifications as we proceed.
DEFINING RESPONSIVE TEACHING

Teaching and learning are interactive  A basic premise of being a teacher is that we engage in meaningful interactions with students and create a learning environment in which every student participates. As teachers, what we do, how we prepare, and how we act all have powerful effects on how students learn and see themselves as learners.

Our interactions with students are constantly informing our understanding about them, including their mastery of content, and—most importantly—their understandings about their identities as learners and their self-esteem. Responsive teaching involves reflecting on the ways in which we interact with our students, and they interact with us and with one another, to form positive and affirming experiences for each student.

What is cultural responsiveness?  Cultural responsiveness expands our capacity to make learning meaningful and successful for every learner every day. It affirms our belief in our students’ potential and possibilities, as well as our roles in shaping student’s identities as learners. Teachers do not exist outside of society. We work within the broad “personal, political, social, and historical context” (Nieto, 2004). Much of what we do and say has been formed by the context in which we live and work.

To be culturally responsive educators means that we must take the time to understand perspectives and ways of being that differ from our own. Further, it involves building connections between these differing perspectives and our work with and for our students (Nieto, 2004; WestEd). As teachers, we are expected to know our students and create learning situations that are based on an understanding about each student. When we take time to understand students’ perspectives and use these to inform our teaching, we open up the spaces needed for our students to learn and see themselves as active and valued participants in the learning community.

What does it mean to be a responsive teacher?  Responsive teaching requires that we have an understanding that our personal, academic, and life experiences are different from those of our students (Melnick & Zeichner, 1998; Zeichner, 1992). If unexamined, these differences can lead to a mismatch between our students’ prior experiences and the lessons we offer. Being a responsive teacher in DYS settings involves learning about:

› The prior experiences of our students;
› How we can use students’ experiences as important and highly valuable resources;
› How students from diverse backgrounds learn best;
› How our own experiences (both in and out of the classroom) influence or impact our work with youth.
To identify your own prior experiences as a learner, consider your responses to the following questions:

**During my secondary school years...**

The relationship that my parents/guardians had with my teachers can best be described as:

One experience that my teacher provided to help me care for others was:

My experiences with peers from a different economic class than mine were:

My experiences with students who had special educational needs were:

My experiences with peers of a race, ethnic, economic, or language background other than my own were:

My experiences with peers who had been involved with the law, the courts, or the justice system were:

Reflect on the ways in which your learning experiences have influenced your thinking about teaching and the beliefs you have about the learners in your classrooms. Reflecting on your prior experiences will also help you think about the ways in which you are open to learning about your students so that you can help create a caring learning environment and a positive learning atmosphere.
Responsive teaching includes an understanding about academic learning that is based on the premise that we learn through meaningful interaction. These interactions include teachers’ interactions with students, teachers’ interactions with other teachers, and students’ interactions with other students. Further, these interactions reflect how students view their capacity to learn and perceive their identity as learners. The Framework of Academic Learning illustrated below was adapted from Schecter & Cummins, 2003:

We learn through meaningful interaction.
Learning occurs when students perceive that they are welcomed into the learning community, and when they believe that teachers have confidence in them and expect them to succeed. For students to invest in learning and participating, they must, on a consistent basis, experience interactions from their teachers and classmates that are both positive and affirming.

At a conference attended by elementary and secondary teachers and administrators about safe schools, the keynote speaker posed the following question, “If you could give students one idea, just one, knowing that they could carry that idea with them throughout their lives, what would it be?” Overwhelmingly, the responses included respect, kindness, civility, and dignity (Charney, 2002).

Building a classroom community that reflects these attributes is essential, and building and sustaining relationships with students is critical to the learning process. Building community, however, entails a great deal more than treating others with kindness. In the example that follows later in this chapter, you will note that the teacher smiled when her student performed a particular task. She smiled to signal her belief that he understood the task, but he had not understood the task’s meaning, and therefore, her positive reaction did not (could not) affirm that learning had occurred.

Building community... entails a great deal more than treating others with kindness.

In the pages that follow this chapter’s case example, readers will find specific suggestions for building community.

DESIGNING LESSONS BASED ON STUDENTS’ PRIOR EXPERIENCES

Students are attracted to learning when their personal, cultural, and literacy experiences are valued by their teachers and peers, and when these experiences are infused into their lessons. Further, learning occurs best when teachers are able to attract students to the personal, literacy, cultural, and world experiences that are part and parcel of what we know as “school.”

To make our classrooms appealing in these ways and congruent with our students’ experiences, we must connect information about each student’s prior experiences to the learning materials and processes. The interview guide on the following page can be used whenever a new student enters or enrolls in your science class. The questions can be modified to enable you to gain as much knowledge as possible about your students.

When there are students whose first language is not English, and/or students who were educated outside of the United States, additional questions should be asked about the student’s prior English language learning and school experiences. Remember, too, that in some cases students may not have had access to formal schooling, or their school days and/or school years may have begun and ended at different times than in the typical U.S. public school schedule.

There are many ways to draw from the information you gain from the interview to support your teaching and work with your student. For example, you might find that a student was learning about genetics in another school, and did not enjoy it or learn much because it had involved memorizing a lot of vocabulary terms and had no obvious connection to the student’s life. With this information, you can plan to approach science vocabulary, or teach genetics standards, in more dynamic and responsive ways.
INTERVIEW GUIDE ABOUT STUDENT’S PRIOR SCIENCE EDUCATION

Student’s name and grade level: Date of Interview: 
Interviewer’s name and position: Interpreter (if applicable):

1. Before coming to this facility, how would you describe your experiences in school?

2. What were you learning in your science class?

3. What did you like about the science class? What did you find interesting?

4. Were there any aspects of your science class that did or didn’t relate to your personal life?

5. What did you find particularly challenging about the class?

6. We will be studying (topics/content to be studied). Have you studied this in school before now? If so, what do you remember learning about it? What did you find particularly interesting? What did you find particularly difficult?

7. How do you learn best? (examples: when teachers use lectures, groupwork, teams, independent projects, etc.)

8. What is something related to science that you would like to be able to understand and do?

9. Describe the types of tests that you usually took in science to assess your progress (essay, multiple choice, etc.). Which types of assessments/tests did you do best on?

11. Were you, or was your teacher, concerned about your progress? If yes, please describe the concerns.

12. Do you have any particular concerns about this class?
**FACILITATING ACTIVE STUDENT PARTICIPATION**

Classrooms are spaces for interaction. In many classrooms, teachers often regard students as passive listeners. Similar to a traffic light, teachers control the “traffic” of conversation, whereby all of the interactions flow through the teacher. In such a model, each time a student speaks, the teacher judges what is said and determines its value. Yet in these classrooms, it is common for only a few students to speak. As teachers, there are many steps we can take to encourage and enable all students to participate meaningfully and actively.

**USING THE CASE EXAMPLE**

Many of these techniques and considerations are presented in concert with the case example on the following page. As you read about Miguel’s classroom experience, think about these questions:

- Does Miguel’s experience ring true for some of the students that you teach? How?
- Do the activities that the teacher uses remind you of the activities that you would do, or that you would not do? How are they similar and how are they different?
- What crucial information might have been gained from interviewing Miguel about his prior learning experiences?
- What do you believe that Miguel’s teacher might have done to support Miguel to learn science?
- What could Miguel’s teacher have done to support Miguel in seeing himself as a person who practices science in his everyday life?
Miguel has been committed to the care of DYS for a month so far. This is the first time he’s been away from home. He misses his family and friends terribly, and has found it difficult to attend to his studies without feeling depressed.

In science, the teacher told Miguel’s class that they would be learning about the genetic probability of determining the sex of a baby. She asked the students what they knew about probability and gender. Some of Miguel’s classmates raised their hands. One by one, his teacher asked these students what they knew about the terms. She responded with comments such as, “Yes, good.” or, “Okay what else do we know?” Miguel wrote these words “gender probly” in his notebook. He was not familiar with these two words, and had a hard time following what his teacher said and did. He couldn’t really grasp what his classmates said about the meaning of the two words.

Miguel’s teacher then showed two coins to the class. She asked for a volunteer to cover the coins with masking tape and write the letters “X” and “X” on each side of one coin, and “X” and “Y” on each side of the other.

Miguel did not volunteer to cover the coins. When his teacher asked for a second volunteer to “flip the coins to see where they landed,” he didn’t volunteer. His teacher then required each of the ten students in the class to flip the coins.

When the teacher called on Miguel, he gave her a vacant look. He looked to his classmates and to the blackboard for hints about what to say or do, but he didn’t see any clues. With the information that he had gained through observing his classmates, he tossed the two coins, watched them land, and smiled when he finished the task of tossing the coins. His teacher believed that Miguel’s actions indicated that he understood the task, and she acknowledged his actions with a smile to signal her belief that he understood what was occurring. However, the next day, when he was given a quiz about the meaning of probability, he wrote “flipping coins.”

In this case example, Miguel was not successful in learning the content—even though his teacher drew from the Massachusetts Curriculum Framework’s high school biology standards and implemented a hands-on activity for each student.

The central components of responsive teaching are outlined in the pages that follow. For ease of reference, ideas about how to rethink or redesign this case example are marked with this symbol of a reflective jewel:
RE-THINKING THE CASE EXAMPLE

With reference to the previous case example, there are a number of ways that the teacher could have increased the likelihood that Miguel would be successful in learning the content of the lesson. Several ideas about how to rethink this case example are marked with the symbol of a reflective jewel. Additionally, think about specific ways that you might redesign the lesson to incorporate the guidelines and suggestions that follow.

**Encouraging active participation**

Being a responsive teacher means taking important purposeful steps to welcome new students. Further, it involves actively facilitating the participation of all students. Students actively participate in different ways, and culture plays an important role in shaping the ways in which students participate. Preparation therefore requires breaking down your lessons and activities so that you are sure that your routines and practices are accessible and that your means of assessment are do-able by all of your students. The steps include:

- Consistent routines that orient new students into the classroom;
- Carefully planned transitions during class time that are predictable and routinized;
- Designing a physical environment that allows students to interact actively and safely with you, and with their classmates (through paired and small groupwork), most of the time.

**Assessing the classroom’s physical set-up**

To build a responsive classroom, take time to “visit” your classroom as if it were your first time there, and respond to the following questions:

- Is there a visual display of the daily language and content objectives that every student can readily see?
- Is there a visual display of the ways in which students will be assessed on the content I am currently teaching?
- Recognizing that safety and security are key issues in all DYS settings, does the physical set-up allow for maximum interaction?

To every extent possible, arrange the seats and classroom space for interaction. For example, if you plan to engage students in paired work, arranging two seats that face each other will physically display this expectation. If you intend to use small group work, organize your classroom so that your intention to use groupwork is displayed.

**Using frequent and routine displays of content and language objectives**

Responsive teaching includes displaying content and language objectives frequently and routinely so that all students can readily obtain the information they need to participate actively in class. This is particularly true for English Language Learners and students from culturally and linguistically diverse experiences (Haynes, 2006; Echevarria, Vogt, and Short, 2004). Furthermore, it is critical that visual displays be viewable by all of the students. When this is not possible, make sure to take time for your students to get up from their seats to view and review the daily language and content objectives, word walls, and other essential displays. When movement is not allowed or possible, plan to bring these important visuals to them on a regular and frequent basis.
Making connections

Much of the research on how the brain works tells us that the brain is an organ that is a connection maker (Caine, Caine, & McClintic, 2004; Caine & Caine, 1994). That is, the brain takes in new information and connects it with what it already knows. Therefore, for students to acquire new knowledge, the following must be present:

- A positive atmosphere;
- Routines and practices that are familiar and predictable, including transitions from one task to the next;
- A learning challenge that builds upon and connects with prior knowledge... and is a bit beyond what the students already know; and
- Active engagement of learners.

Using explicit and predictable routines in the classroom helps students engage in habits of thinking and doing. Understanding the routines that occur in each class setting allows students to make connections between what they know and have experienced and new information.

In Miguel’s case, he was not sure what the lesson was about, or what tasks were expected of him. He was not able to recognize clues that would enable him to proceed. His inability to connect to the lesson highlights the need to put routines in place to lower students’ anxiety so that they can succeed.

Linking concepts to students’ prior knowledge

While the teacher did ask students to volunteer their background knowledge about the probability of determining the sex of a baby, not every student was required to provide this information. Additionally, the teacher might have connected the lesson to students’ own lives in multiple ways through questions or discussions about their own experiences anticipating births or caring for babies.

Making connections to explicit language objectives

Language objectives refer to the methods that will be used for students to communicate their knowledge and understanding of the lesson (Echevarria, Vogt, & Short, 2004). For example, a language objective might state that:

- Each student will write a prediction about the coin toss activity. Students will share the prediction with a partner;
- Students will discuss what they know about what determines whether a couple will have a son or a daughter;
- Each pair will report their findings to the whole class demonstrating how the X and Y chromosomes play a part in determining the sex of a baby;
- Students will write five things they already know about a topic and then discuss these with a partner;
- Each student will write a paragraph about...
**Language Objectives** might have been very helpful in teaching Miguel about the probability of genetics; some examples would be:

- Each student will discuss what they know about the factors that determine whether a couple will have a baby boy or girl.
- Each student will write a paragraph about the ways in which the sex of a baby is determined.

**Making connections to explicit content objectives**

Content objectives refer to brief sentences that summarize the purpose of the daily lesson. It is helpful to write clearly defined content objectives on the board for your students (Echevarria, Vogt, & Short, 2004). These objectives (i.e., what students will be able to Know, Understand, and Do) should be introduced at the beginning of each lesson and revisited at the end of each lesson to determine if they have been met.

**Content Objectives** that might have been useful in Miguel’s classroom include (for example):

- Students will learn about genetic probability. Using a coin toss, students will make predictions about the genetic probability of determining the sex of a child
- Students will learn key vocabulary words and phrases used to describe genetic probability

Both language and content objectives should be connected to the results of formal and informal pre-assessment activities so that there are clear connections between students’ prior content knowledge and understanding, as well as their literacy and numeracy skills.

**Highlighting key vocabulary**

All subject matter uses its own specialized vocabulary, and this vocabulary is often crucial to demonstrating mastery of the content in that subject. Determine each of the key vocabulary words, phrases, and concepts that are needed for your lessons. Visually display these on a word wall or other arrangement so that all students can readily see them every day. You can support students’ connections to the academic vocabulary and concepts by explaining how these terms are tied to a practical application in students’ real lives.

In Miguel’s lesson, there are many key vocabulary words that would have been required. These include probability, genetics, chromosomes, genotype, and others. Each of these words is tied to a specific context—creating a new human being. The context sets the stage for learning, and can be made transparent in many ways. For example, viewing the Nova series, The Miracle of Life (see the web address below) could have provided a rich context for Miguel.

http://www.pbs.org/wgbh/nova/miracle/program.html

Students can create visual displays about the content presented in this video. Types of visual displays can include artistic drawings, individually designed index-sized cards of key vocabulary terms, as well as poetry.
Routinely displaying how students will be assessed

Assessment is a key means for you to be informed about the success of your lessons, and for your students to be informed about the success of their learning. Determine the type of assessment that you will use, and be sure to familiarize each student with the means by which you will assess his/her learning. To do this:

- Create or identify an assessment tool that each of your students can complete;
- Before the lesson begins, explicitly inform the students about the ways in which they will be assessed;
- Provide students with multiple opportunities to practice the means by which you will be assessing them.

A variety of assessment tools will be needed to address the range of ages, grades, learning needs, and prior academic experiences and abilities of the students in your class. Each of these assessment tools should first be modeled for students to ensure the highest rate of success. For example, if you require a one-page essay, it will be important to show students a sample of a one-page essay and support them in the writing process of it.

Providing predictable routines that engage active participation

To every extent possible, create predictable routines that allow students to follow this sequence:

1. Observe the teacher modeling the activities and tasks students will be expected to do
2. Practice these activities and tasks with another student as a partner
3. Discuss the outcome of the activities and tasks with a partner or in a small group
4. Conduct the activities independently or as a group
5. Reflect on the activities independently or as a group
6. Have opportunities to teach the activities or tasks to others

Model each activity for your students, including language and content objectives, as well as key vocabulary words and phrases, in the model activities. Once you have modeled each activity, engage students in a paired practice activity. This may be followed by a small-group activity.

The purpose of the modeling paired work small group sequence is to provide opportunities for students to observe new content being used, and to practice the activities associated with it. Once this has been accomplished, ask the students to reflect on the modeling and practice activities. These may be done independently or as a group. Finally, whenever possible, it is advantageous for students to teach lessons to others. The activity of students teaching students is intended to assist the student/teachers as well as the student/learners in acquiring and mastering new knowledge.
Summary—Planning your own lessons

In review, to increase the likelihood that your students will be successful in learning the content of the lessons you teach, complete these nine steps before a lesson is taught:

1. Review the purpose of the lesson;
2. Assemble the materials that will be used to teach the lesson;
3. Determine the language and content objectives that will be displayed on the board as part of the daily routine;
4. Predict what you believe should be displayed on the board to help students to learn, practice, and use the knowledge gained from the lesson;
5. Determine the key vocabulary words and phrases that are necessary for students to learn and master; write these vocabulary words on the board or create a “word wall” that is readily visible and available to all students;
6. While taking measures to ensure maximum safety and security, arrange students' desks, chairs, and tables, as well as your own, for maximum interaction;
7. Plan the ways that you will make connections between each student’s background knowledge with the content being studied;
8. Plan for guided practice, paired practice, and independent practice of lesson concepts;
9. Where possible, plan for students to teach the concepts to one another and/or reinforce their learning.

Sharing your ideas with others

You may have many additional ideas for being a responsive teacher. Plan to share ideas with your teaching colleagues and others to spread the word about what works in your classroom. We are all important and integral partners in the work of engaging students to be successful learners and members of their learning community. We all have an important role in making this happen!
References


FRAMING CURRICULUM AND INSTRUCTION
FRAMING CURRICULUM AND INSTRUCTION

CURRICULUM and INSTRUCTION—DEFINING THE TERMS

DYS EDUCATIONAL PHILOSOPHY

A SYSTEM for CURRICULUM & INSTRUCTION in DYS

DOE’S GUIDING PRINCIPLES for SCIENCE CURRICULUM & INSTRUCTION

STRATEGIES for DIFFERENTIATION

DIFFERENTIATION of INSTRUCTION

REPRESENTING DYS PROFESSIONAL DEVELOPMENT GOALS

FROM FRAMEWORKS TO EFFECTIVE INSTRUCTION
**CURRICULUM AND INSTRUCTION—DEFINING THE TERMS**

All fields of endeavor have specialized vocabulary or jargon. This kind of terminology can be very useful, enabling practitioners to use a kind of “insider shorthand” to communicate with others in the field. It is essential, however, that terms be defined, so that the same words mean the same things to all who use and hear them. Some of the most frequently used terms in the field of education include:

| **CURRICULUM** | Ideas, skills, processes, and content that educators identify as important for students to learn in each subject area; curriculum is the “what” of education |
| **INSTRUCTION** | Interaction between teacher and student, or the actual activities that communicate and review knowledge, understanding, or skill; instruction is the “how” of education |
| **FRAMEWORKS** | Curriculum frameworks in each content area, consistent throughout Massachusetts |
| **STRANDS** | Major organizing principles for learning in each content area |
| **STANDARDS** | Learning goals in each content area, delineated within each strand |
| **ASSESSMENTS** | Various methods to gather evidence of students’ progress towards achieving the learning objectives |

Good curriculum translates broad, overarching frameworks, strands, and standards into concrete lessons, mini-units, daily activities, assessments, and supporting materials. These provide the means through which teachers engage their students, and lead them through actions that will result in students’ meeting their learning objectives.

In every classroom, teachers build their curricular programs by:

- Defining learning objectives based on the frameworks, strands and standards;
- Assessing current levels of knowledge, understanding, and skill among all students in the classroom;
- Planning activities and selecting materials that will support the learning objectives and are differentiated for diverse learners;
- Implementing activities and using materials that are appropriate to the needs, interests, backgrounds, and experiences of their students;
- Assessing students’ growth in meeting learning objectives.

In DYS settings, instruction needs to be especially interactive and engaging. The challenge is to help DYS teachers stress academic rigor and simultaneously differentiate instruction to respond to variety in the backgrounds, abilities, interests, and learning styles among diverse and highly mobile students.
DYS EDUCATIONAL PHILOSOPHY

DYS is committed to providing an education program for all students in the DYS system that is in compliance with the Massachusetts state curriculum standards. The instruction, assessment, and the DYS Instructional Guides are organized around key themes and essential learning outcomes that are modified for various student placements (detention, assessment, and treatment). All education is delivered with an understanding of the diversity of the student population, curriculum, instruction, and assessment planning include components of differentiation, respect for cultural and linguistic diversity, and a commitment to enhancing students’ literacy and numeracy skills.

A SYSTEM for CURRICULUM & INSTRUCTION in DYS

DYS teachers face multiple challenges planning and delivering effective science curriculum. These include addressing the Massachusetts Science Frameworks, aligning instruction with MCAS and GED test areas, minimizing duplication of content, teaching a transient population, and addressing the need for differentiated instruction. Youth come to DYS with vastly differing sets of skills, abilities and background knowledge, as well as their own hopes, fears, experiences and aspirations. Additionally, there is a range of different settings and educational programs within the DYS education system, as well as great variation in the length of time young people spend in our programs.

A great many factors —both educational and not—constantly impact our students’ learning, and they all have an effect on what we can do in the DYS classroom. An equally intense challenge is engaging students in the learning process. DYS students are racially and ethnically diverse. Most are racial minorities, many are poor, and the overwhelming majority have experienced discrimination, inequity, trauma, and violence.

Science instruction must speak to our students’ desires to understand their lives: who they are and how the world functions. Relevance and applicability are crucial for personal growth, to motivate learning, and to bring meaning to what happens in the classroom.

We must also be attentive to the wide range of possibilities for our students when they leave the DYS system. Our most fundamental goal is to prepare them for a successful future outside of DYS, which may include returning to high school, passing MCAS or GED examinations, and entering the Job Corps, employment, or a college, university, or other learning option. Given the extraordinary range of variables in the DYS system, our challenge is to develop a system of education that is coherent and consistent, as well as flexible. To meet these challenges, we have developed a highly adaptable curriculum, organized around broad topics and reflecting key principles for science instruction in DYS settings. As teachers, we must strive to meet our students where they are now, build learning activities around their interests, and tailor instruction to address their individual learning styles and preferences. Reaching out in these ways enables students to use their own background knowledge to acquire and retain new skills and new learning.

Science instruction must speak to our students’ desires to understand their lives: who they are and how the world functions. Relevance and applicability are crucial...
DOE’S GUIDING PRINCIPLES FOR SCIENCE CURRICULUM & INSTRUCTION

The Massachusetts Department of Education’s Science and Technology/Engineering Curriculum Framework is built around ten principles that show how educators can create educational environments characterized by curiosity, persistence, respect for evidence, open-mindedness balanced with skepticism, and a sense of responsibility. A fuller description of these guiding principles is provided in the Framework document. All teachers in the DYS system have and refer to a copy of this extensive and important document.

INCLUDE ALL STUDENTS
A comprehensive science program enrolls all students from PreK through grade 12.

CONNECT FUNDAMENTAL CONCEPTS
An effective program builds students’ understanding of the fundamental concepts of each domain of science and their understanding of the connections across these domains and to basic concepts.

MATH IS AN ESSENTIAL TOOL
Science and technology/engineering are integrally related to mathematics.

ADDRESS PRIOR KNOWLEDGE AND/OR MISCONCEPTIONS
An effective program addresses students’ prior knowledge and misconceptions.

EMPHASIZE METHODS
Investigation, experimentation, and problem solving are central to science and technology/engineering education.

BUILD AND DEVELOP LITERACY SKILLS AND KNOWLEDGE
Build upon and develop reading, writing, and communication skills throughout the science program.

MAINTAIN HIGH EXPECTATIONS
Students learn best in an environment that conveys high academic expectations for all students.

VARY ASSESSMENTS
Assessment in science and technology/engineering serves to inform student learning, guide instruction, and evaluate student progress.

ENCOURAGE COLLABORATION AND COMMUNICATION
An effective program in science and technology/engineering gives students opportunities to collaborate in scientific and technological endeavors and communicate their ideas.

PLAN FOR COHESIVE PROGRAMMING
A coherent science and technology/engineering program requires district- or system-wide planning and ongoing support for implementation.
Look over the **DOE's Guiding Principles** on the previous page (these are excerpted from the Science and Technology/Engineering Curriculum Framework)

Compare these with the **Effective Teaching Practices for Youth in DYS Settings** that were outlined in the introductory section of this guide. Think about how they are similar and how they are different.

Choose 3 principles that seem especially important for youth in DYS settings. How can you promote these principles in your classroom?

Choose 1 that seems like the greatest stretch for a science class for DYS youth. Why does this seem to be a stretch? Talk to your colleagues and coaches about how to promote that principle in your classroom.

Which of the principles would be most important to use in planning curriculum, instruction, and assessment at the particular site where you teach? Why?
STRATEGIES FOR DIFFERENTIATION

The Access Center in Washington, DC has created a number of Information Briefs available for free download from the internet. There are several briefs regarding science teaching that provide strategies and resources to help teachers differentiate instruction by:

- Assessing cognitive readiness by, for example, using KWL charts (charts that ask students to identify what they already Know, what they Want to know, and what they have Learned about a topic), pre-tests, or other assessments;
- Inventorying student interests by including students in planning processes; and
- Identifying students’ learning profiles by determining their
  - Learning Styles (is the student a visual, auditory, tactile, linguistic or kinesthetic learner?);
  - Multiple Intelligences (i.e., Linguistic, Logical-Mathematical, Spatial, Bodily-Kinesthetic, Musical, Interpersonal, Intrapersonal, and Naturalist intelligences);
  - Grouping Preferences (does the student work best individually, with a partner, or in a large group?); and
  - Environmental Preferences (does the student need lots of space or a quiet area to work?).

While acknowledging that there is no one-size-fits-all recipe for differentiation, Dr. Carol Ann Tomlinson presents a comprehensive description of specific strategies for differentiation in her book, *How to Differentiate Instruction in Mixed-Ability Classrooms*, published by the Association of Supervision and Curriculum Development (2nd edition, 2001).

Examples of some differentiation strategies include:

<table>
<thead>
<tr>
<th>STRATEGY</th>
<th>RESPONDS TO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiered Assignments and Products</td>
<td>Readiness</td>
</tr>
<tr>
<td>Compacting</td>
<td>Readiness</td>
</tr>
<tr>
<td>Interest Centers or Interest Groups</td>
<td>Interest &amp; Readiness</td>
</tr>
<tr>
<td>Flexible Grouping</td>
<td>Interest, Readiness, &amp; Learning Profiles</td>
</tr>
<tr>
<td>Learning Contracts</td>
<td>Readiness &amp; Learning Profiles</td>
</tr>
<tr>
<td>Choice Boards</td>
<td>Readiness, Interest, &amp; Learning Profiles</td>
</tr>
<tr>
<td>Independent Research</td>
<td>Interest &amp; Diverse Backgrounds</td>
</tr>
</tbody>
</table>

The Access Center has also provided a very useful chart for planning and implementing strategies for differentiation. The chart is available at no cost from The Access Center’s website.

http://www.k8accesscenter.org/index.php/category/science
DIFFERENTIATION OF INSTRUCTION

By matching strategies for instruction to students’ characteristics, teachers can strengthen learning for everyone in the classroom. Differentiating instruction allows all students to access the same classroom curriculum.

WHAT CAN BE DIFFERENTIATED?

CONTENT
What you want students to learn

PROCESS
How students learn the content

PRODUCT
How a student demonstrates the degree to which content has been learned

WHAT SHOULD DIFFERENTIATION RESPOND TO?

Differences in COGNITIVE READINESS
Students’ skill levels and prior knowledge

Differences in INTERESTS
Topics that are motivating and respond to students’ experiences

Differences in LEARNING PROFILES
- Learning Styles
- Multiple Intelligences
- Grouping Preferences
  - Environmental Preferences
Examples of the three overarching priorities in DYS Professional Development are integrated throughout this Instructional Guide, where they are represented by the following symbols:

**Standards-Based Curriculum**

Assist teachers in the implementation of DYS standards-based curriculum, as measured by learning objectives connected to the state curriculum frameworks, and the effective use of the DYS Instructional Guides, instructional resources, and multiple means of assessment.

**Differentiated Instruction**

Prepare teachers to differentiate using standards-based instructional practices suitable to a juvenile justice system, as measured by the teacher’s development and demonstration of curriculum, instruction, and assessment appropriate to students’ prior knowledge, interests, and learning styles and needs.

**Literacy and Numeracy**

Promote literacy and numeracy, as measured by the teacher’s demonstration and assessment of student listening, speaking, reading, writing and math across all content areas, in all trainings, resources, and curriculum.

These symbols are strategically placed throughout the guide to draw attention to areas where each of the three priorities is strongly emphasized.

Exemplar: Later in this Instructional Guide, a lesson on the “Web of Life” is presented as an exemplary Problem of the Day in the Biology strand. In that lesson, these icons are used to draw attention to each of the priorities.

When reviewing other exemplars, or developing your own curricular materials, think about the ways in which each of these priorities can be emphasized to enrich your teaching and your students’ learning.
Present important knowledge in each subject area, broken down into key categories known as:

**STRANDS**

Break each category down into specific, measurable components known as:

**STANDARDS**

Indicate what information teachers need to teach by using, researching, downloading, or developing their own lesson plans, problems, and units, known as:

**CURRICULUM** (or curricula, the plural)

Shapes interactions with students that build upon students’ knowledge and skills through:

**SB** Standards-Based Curriculum

Lessons and problem-solving scenarios that address standards using examples drawn from students’ own experiences and backgrounds

**DI** Differentiated Instruction

Diverse materials and methods of interacting that address students’ different learning styles, backgrounds, needs, challenges, and strengths

**LN** Literacy and Numeracy

Focus on literacy and numeracy throughout all teaching and learning activities in DYS
and emphasized
FOUR STRANDS of the SCIENCE CURRICULUM FRAMEWORK

WHICH STANDARDS ARE EMPHASIZED IN DYS?

SUMMARY OF STRANDS AND EMPHASIZED STANDARDS IN SCIENCE

- **SCIENTIFIC INQUIRY**
  Make observations, raise questions, and formulate hypotheses • Design and conduct scientific investigations • Analyze and interpret results of scientific investigations • Communicate and apply the results of scientific investigations

- **BIOLOGY**
  Chemistry of Life • Cell Biology • Genetics • Anatomy and Physiology • Evolution and Biodiversity • Ecology

- **CHEMISTRY**
  Properties of Matter • Atomic Structure and Nuclear Chemistry • Periodicity • Chemical Bonding, Chemical Reactions and Stoichiometry • States of Matter, Kinetic Molecular Theory, and Thermochemistry • Solutions, Rates of Reaction, and Equilibrium • Acids and Bases and Oxidation–Reduction Reactions

- **INTRODUCTION TO PHYSICS**
  Motion and Forces • Conservation of Energy and Momentum • Heat and Heat Transfer • Waves • Electromagnetism • Electromagnetic Radiation

FROM STRANDS and STANDARDS TO DAILY INSTRUCTION

COMPONENTS (TEMPLATE) for a MINI-UNIT

WHAT CAN YOU DO IN A DAY? (PROBLEMS OF THE DAY)
FOUR STRANDS of the SCIENCE CURRICULUM FRAMEWORK

In addition to the key DYS principles and guiding principles for science discussed in the previous section, the strands and standards articulated in the Massachusetts Science and Technology/Engineering Curriculum Framework are crucial components for planning curriculum and instruction in DYS settings. The four strands include:

- **SCIENTIFIC INQUIRY**
- **BIOLOGY**
- **CHEMISTRY**
- **INTRODUCTION TO PHYSICS**

Each of these four strands includes many detailed learning standards. DYS students’ science competencies span a wide age and grade range; this guide focuses primarily on high school standards. Careful analysis has shown that certain standards predominate in the MCAS for grades 8 and 10 and/or the GED tests. These particular learning objectives are considered key learning standards within DYS, because they occur with great frequency on these important assessments, and are most useful and applicable in employment, life skills, and future learning. The strands and key standards emphasized in this manual are outlined on the following pages.

All DYS teachers should also have and refer to their own copies of the complete Framework document. The full Framework not only offers detailed standards, but also provides excellent curriculum, instruction, and assessment suggestions and resources. A downloadable PDF of the entire Framework is available on the Massachusetts Department of Education’s website.

As discussed in previous chapters, the challenges to developing an organized and systematic curriculum for the DYS educational system include high mobility as well as extraordinary diversity of ages, skills, background knowledge, personal backgrounds and history, and more. In response to these challenges, the Department of Youth Services, Commonwealth Corporation, and the Hampshire Educational Collaborative worked together to develop a flexible curriculum that emphasizes key standards, reflects important principles, standards, essential questions, and big ideas, and is aligned with an extensive program of professional development and coaching.

A flexible curriculum ... emphasizes key standards and integrates important principles, high standards, essential questions, and big ideas.

The full Framework... also provides excellent curriculum and instruction, as well as suggestions and resources for assessment.
WHICH STANDARDS ARE EMPHASIZED IN DYS—AND WHY?

In each of the strands of science that will be addressed in this Instructional Guide, we emphasize certain key standards in DYS settings. Science teachers and coaches have selected the “emphasized standards” outlined on the following pages because they meet the following broad criteria:

1. These standards help identify broad concepts that can guide student learning and help them to think about the larger picture and use science facts, concepts, and modes of inquiry in all aspects of their lives.

2. They are tied to the principles for science instruction and to the strands and standards from the Massachusetts Curriculum Framework; they promote high standards and rigor.

3. Questions and problems associated with these standards occur with the greatest frequency on the Massachusetts Comprehensive Assessment System exams, the National Science Education Standards (NSES), and/or the GED.

4. These scientific concepts, materials, and modes of inquiry that are most applicable and fundamental to employment, life skills, and future learning.

5. These ideas are broad enough to guide teachers in planning instruction throughout the year, while allowing enough flexibility for individual teachers and programs to choose many of their own materials and meet individual students’ needs.

6. Emphasized standards provide a measure of unity among DYS programs, and provide a mechanism for sharing lessons and units among DYS teachers.

All strands of instruction, and all standards within these strands, are outlined in the full framework documents available for download as PDF or Word files from the web address listed above. The following pages review those standards that should be emphasized in DYS instruction.
**SCIENTIFIC INQUIRY**

*Make observations, raise questions, and formulate hypotheses*

- Design and conduct scientific investigations
- Analyze and interpret results of scientific investigations
- Communicate and apply the results of scientific investigations

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**SCIENTIFIC INQUIRY SKILL STANDARDS ★**

**SIS 1  Make observations, raise questions, and formulate hypotheses**

- Observe the world from a scientific perspective.
- Pose questions and form hypotheses based on personal observations, scientific articles, experiments, and knowledge.
- Read, interpret, and examine the credibility and validity of scientific claims in different sources of information, such as scientific articles, advertisements, or media stories.

**SIS 2  Design and conduct scientific investigations**

- Articulate and explain the major concepts being investigated and the purpose of an investigation.
- Select required materials, equipment, and conditions for conducting an experiment.
- Identify independent and dependent variables.
- Write procedures that are clear and replicable.
- Employ appropriate methods for accurately and consistently:
  - Making observations
  - Making and recording measurements at appropriate levels of precision
  - Collecting data or evidence in an organized way
- Properly use instruments, equipment, and materials (e.g., scales, probeware, meter sticks, microscopes, computers) including set-up, calibration (if required), technique, maintenance, and storage.
- Follow safety guidelines.

**SIS 3  Analyze and interpret results of scientific investigations**

- Present relationships between and among variables in appropriate forms:
  - Represent data and relationships between and among variables in charts and graphs.
  - Use appropriate technology (e.g., graphing software) and other tools.
- Use mathematical operations to analyze and interpret data results.
- Assess the reliability of data and identify reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- Use results of an experiment to develop a conclusion to an investigation that addresses the initial questions and supports or refutes the stated hypothesis.
- State questions raised by an experiment that may require further investigation.
**SIS 4**  
**Communicate and apply the results of scientific investigations**
- Develop descriptions of and explanations for scientific concepts that were a focus of one or more investigations.
- Review information, explain statistical analysis, and summarize data collected and analyzed as the result of an investigation.
- Explain diagrams and charts that represent relationships of variables.
- Construct a reasoned argument and respond appropriately to critical comments and questions.
- Use language and vocabulary appropriately, speak clearly and logically, and use appropriate technology (e.g., presentation software) and other tools to present findings.
- Use and refine scientific models that simulate physical processes or phenomena.

★ **These standards are preceded by the initials SIS, for Science Inquiry Skills. These skills should be explored, practiced, and applied throughout all teaching and learning activities in science.**
Describe the basic molecular structures and primary functions of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).

Explain the role of enzymes as catalysts that lower the activation energy of biochemical reactions. Identify factors such as pH and temperature that have an effect on enzymes.

Relate cell parts/organelles (plasma membrane, nuclear envelope, nucleus, nucleolus, cytoplasm, mitochondrion, endoplasmic reticulum, Golgi apparatus, lysosome, ribosome, vacuole, cell wall, chloroplast, cytoskeleton, centriole, cilium, flagellum, pseudopod) to their functions. Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, facilitated diffusion, active transport).

Identify the reactants, products and basic purposes of photosynthesis and cellular respiration. Explain the interrelated nature of photosynthesis and cellular respiration in the cells of photosynthetic organisms.

Describe the cell cycle and the process of mitosis. Explain the role of mitosis in the formation of new cells, and its importance in maintaining chromosome number during asexual reproduction.

Describe how the process of meiosis results in the formation of haploid cells. Explain the importance of this process in sexual reproduction, and how gametes form diploid zygotes in the process of fertilization.

Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic code. Explain the basic process of transcription and translation and how they result in the expression of genes. Distinguish among the end products of replication, transcription, and translation.

Explain how mutations in the DNA sequence of a gene may or may not result in phenotypic change in an organism. Explain how mutations in gametes may result in phenotypic changes in offspring.

Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, codominant, sex-linked, polygenic, incomplete dominance, multiple alleles).

Describe how Mendel’s law of segregation and independent assortment can be observed through patterns of inheritance (e.g., dihybrid crosses).
Recognize that the body’s systems interact to maintain homeostasis. Describe the basic function of a physiological feedback loop.

Explain how evolution is demonstrated by evidence from the fossil record, comparative anatomy, genetics, molecular biology, and examples of natural selection.

Describe species as reproductively distinct groups of organisms. Recognize that species are further classified into a hierarchical taxonomic system (kingdom, phylum, class, order, family, genus, species) based on morphological, behavioral, and molecular similarities. Describe the role that geographic isolation can play in speciation. (Note: GED questions focus heavily on classifications.)

Explain how evolution through natural selection can result in changes in biodiversity through the increase or decrease of genetic diversity within a population.

Use a food web to identify and distinguish producers, consumers, and decomposers, and explain the transfer of energy through trophic levels. Describe how relationships among organisms (predation, parasitism, competition, commensalisms, mutualism) add to the complexity of biological communities.

Explain how water, carbon, and nitrogen cycle between abiotic resources and organic matter in an ecosystem, and how oxygen cycles through photosynthesis and respiration.

These standards are preceeded by the initial B for Biology. They explore the related areas of Chemistry of Life, Cell Biology, Genetics, Anatomy and Physiology, Evolution and Biodiversity, and Ecology.
**EMPHASIZED CHEMISTRY STANDARDS**

**C 1.1** Identify and explain physical properties (e.g., density, melting point, boiling point, conductivity, malleability) and chemical properties (e.g., the ability to form new substances). Distinguish between chemical and physical changes.

**C 1.2** Explain the difference between pure substances (elements and compounds) and mixtures. Differentiate between heterogeneous and homogeneous mixtures.

**C 2.2** Describe Rutherford’s “gold foil” experiment that led to the discovery of the nuclear atom. Identify the major components (protons, neutrons, and electrons) of the nuclear atom and explain how they interact.

**C 2.5** Identify the three main types of radioactive decay (alpha, beta, and gamma) and compare their properties (composition, mass, charge, and penetrating power).

**C 3.1** Explain the relationship of an element’s position on the periodic table to its atomic number. Identify families (groups) and periods on the periodic table.

**C 3.3** Relate the position of an element on the periodic table to its electron configuration and compare its reactivity to the reactivity of other elements in the table.

**C 4.1** Explain how atoms combine to form compounds through both ionic and covalent bonding. Predict chemical formulas based on the number of valence electrons.

**C 4.4** Use valence-shell electron-pair repulsion theory (VSEPR) to predict the molecular geometry (linear, trigonal planar, and tetrahedral) of simple molecules.

**C 4.6** Name and write the chemical formulas for simple ionic and molecular compounds, including those that contain the polyatomic ions: ammonium, carbonate, hydroxide, nitrate, phosphate, and sulfate.

**C 5.1** Balance chemical equations by applying the laws of conservation of mass and constant composition (definite proportions).

**C 5.2** Classify chemical reactions as synthesis (combination), decomposition, single displacement (replacement), double displacement, and combustion.
Using the kinetic molecular theory, explain the behavior of gases and the relationship between pressure and volume (Boyle’s law), volume and temperature (Charles’s law), pressure and temperature (Gay-Lussac’s law), and the number of particles in a gas sample (Avogadro’s hypothesis). Use the combined gas law to determine changes in pressure, volume, and temperature.

Using the kinetic molecular theory, describe and contrast the properties of gases, liquids, and solids. Explain, at the molecular level, the behavior of matter as it undergoes phase transitions.

Identify and explain the factors that affect the rate of dissolving (e.g., temperature, concentration, surface area, pressure, mixing).

Identify the factors that affect the rate of a chemical reaction (temperature, mixing, concentration, particle size, surface area, catalyst).

Define the Arrhenius theory of acids and bases in terms of the presence of hydronium and hydroxide ions in water and the Bronsted-Lowry theory of acids and bases in terms of proton donors and acceptors.

Relate hydrogen ion concentrations to the pH scale and to acidic, basic, and neutral solutions. Compare and contrast the strengths of various common acids and bases (e.g., vinegar, baking soda, soap, citrus juice).

★ These standards are all preceded by the initial C, for Chemistry. They explore the related areas of Properties of Matter, Atomic Structure and Nuclear Chemistry, Periodicity, Chemical Bonding, Chemical Reactions and Stoichiometry, States of Matter, Kinetic Molecular Theory, and Thermochemistry, Solutions, Rates of Reaction, and Equilibrium, and Acids and Bases and Oxidation–Reduction Reactions.
Distinguish between displacement, distance, velocity, speed, and acceleration. Solve problems involving displacement, distance, velocity, speed, and constant acceleration.

Interpret and apply Newton’s three laws of motion.

Use a free-body force diagram to show forces acting on a system consisting of a pair of interacting objects. For a diagram with only co-linear forces, determine the net force acting on a system and between the objects.

Describe Newton’s law of universal gravitation in terms of the attraction between two objects, their masses, and the distance between them.

Interpret and provide examples that illustrate the law of conservation of energy.

Describe both qualitatively and quantitatively how work can be expressed as a change in mechanical energy.

Explain how heat energy is transferred by convection, conduction, and radiation.

Explain how heat energy will move from a higher to a lower temperature until equilibrium is reached.

Explain the relationships among temperature changes in a substance, the amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance. Explain the relationships among temperature changes in a substance, the amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance.

Describe the measurable properties of waves (velocity, frequency, wavelength, amplitude, period) and explain the relationships among them. Recognize examples of simple harmonic motion.

Recognize that an electric charge tends to be static on insulators and can move on and in conductors. Explain that energy can produce a separation of charges.

Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm’s law).
EMPHASIZED PHYSICS STANDARDS (continued)

**P 5.5** Explain how electric current is a flow of charge caused by a potential difference (voltage), and how power is equal to current multiplied by voltage.

**P 6.2** Describe the electromagnetic spectrum in terms of frequency and wavelength, and identify the locations of radio waves, microwaves, infrared radiation, visible light (red, orange, yellow, green, blue, indigo, and violet), ultraviolet rays, x-rays, and gamma rays on the spectrum.

★ These standards are all preceeded by the initial P, for Physics. They explore the related areas of Motion and Forces, Conservation of Energy and Momentum, Heat and Heat Transfer, Waves, Electromagnetism, and Electromagnetic Radiation.
To support the emphasized standards, DYS teachers use mini-units, lessons, and Problems of the Day that are directly tied to learning standards.

Standards-based planning involves having a clear relationship among at least these seven things:

- **TOPICS** and sub-topics
- **STANDARDS** to be taught and assessed
- **ACTIVITIES** and tasks to teach and demonstrate knowledge and skills in pursuit of learning objectives
- **PRODUCTS** and performances that form the basis for assessment of progress toward learning objectives
- **CRITERIA** for assessment, based on the standards and the learning objectives associated with them
- **SCORING GUIDES** to assess and communicate about student learning
- **EXEMPLARY**s to clarify expectations for student learning and aid in evaluating and revising the instruction

Learning objectives for each lesson and mini-unit should be taken directly from the language of the Standards addressed by that activity.
USING THE EMPHASIZED LEARNING STANDARDS

Mapping backwards:

Select a learning project or activity with strong science components:

What do you want students to be able to DO?

Review the emphasized science standards: What do students need to KNOW and UNDERSTAND to be able to do this project or activity?

Identify the standards that are supported by your lesson or activity: How will students DEMONSTRATE the degree to which they know and understand the material?

Mapping forwards:

Look over the science standards and identify the standard(s) you want to address in your project or activity: How will students DEMONSTRATE the degree to which they know and understand the standard?

Choose or brainstorm activities or projects that you could do in your classroom to teach, reinforce, or extend this standard: What will students need to KNOW and UNDERSTAND to be able to engage with this project or activity?

Select the learning project or activity you will use to help students learn this standard: What do you want students to be able to DO in, or as a result of, this activity?
COMPONENTS (TEMPLATE) FOR A MINI-UNIT

LEARNING OBJECTIVES

By the end of this mini-unit, students should:

**KNOW** (factual information, basic skills)

**UNDERSTAND** (big ideas, concepts, Essential Questions)

And therefore be **ABLE TO DO** (final assessment, performance, measurement of objectives)

EMPHASIZED STANDARDS

Based on what students should know, understand, be able to do

PRE-ASSESSMENT

How will you determine students' readiness for this unit?

What data will you collect?

What survey of prerequisite learning will you use?

(i.e., KWL charts, journal prompts, oral surveys)

RESOURCES AND MATERIALS

Should reflect differences in students' readiness to learn (prerequisite learning), interests (choices), and learning profiles (learning styles, environmental and grouping preferences)

OUTLINE OF LESSONS

Lesson tasks and activities to support students' achievement of learning objectives

**INTRODUCTORY**

Stimulate student interest and motivation to participate

**INSTRUCTIONAL**

Students make meaning of content information and begin to demonstrate, through ongoing assessment, what they know and understand

**CULMINATING**

Usually a final assessment in which students demonstrate their level of achievement with regard to the learning objectives.

REFLECTION

After the mini-unit is completed, make note of adjustments you would make when using this unit again.

SCIENCE teaching in DYS schools
WHAT CAN YOU DO IN A DAY?

One of the basic conditions of teaching in DYS is that many of our students are with us for only a short period of time. Many DYS youth are in detention sites, where they may spend only one or two days. While some teachers may consider this an untenable situation, DYS teachers can make a value of this necessity—not by repetitive skill drills or worksheets, but by focusing on important skills and content through a **Problem of the Day**.

Each Problem of the Day should be linked to learning standards, clear objectives, pre-assessments, and reflection, and should organize instruction for the entire science period. Some of these problems may stretch over more than one day if desired; teachers and students can work creatively to solve the problem, change the problem repeatedly to reflect their own interests, experiences, and background knowledge, and then solve the problem again and again. The Problem of the Day approach is flexible and fun, and ensures that even in just one day, you are helping students learn something that they can really use.

The Problem of the Day can be differentiated to respond to students’ diverse backgrounds, cognitive readiness, and learning styles, and is particularly useful in detention settings, where student mobility may be extremely high. Teachers in assessment, short-term, long-term and community-based diversion programs can also use a Problems of the Day to:

- **ENLIVEN** a longer unit of study,
- **SIGNAL A CHANGE** from one unit to another, or
- **REPEAT** what students have already studied, so they can practice and connect their new knowledge with what they already know and can do.

Problems of the Day are aligned with specific strands and standards of the Curriculum Framework, so teachers in all settings can feel confident that they are using instructional time in ways that make a difference for their students. Examples of interesting and engaging Problem of the Day techniques are provided in the next section of this guide, which includes a wide array of resources for each strand.
SEQUENCING INSTRUCTION IN DYS

Integrating Scientific Inquiry and Math Skills

PRACTICE THE 5Es

Engage
Explore
Explain
Extend
Evaluate

Students learn science by doing science.
SCIENTIFIC INQUIRY SKILLS ARE ESSENTIAL TO GOOD TEACHING and SHOULD BE INTEGRATED INTO ALL SCIENCE TOPICS AND STRANDS.
Research indicates that integrated instructional science units are more effective than typical laboratory, lecture-based classrooms in helping diverse groups of students progress toward three crucial goals: Improving mastery of subject matter, Developing scientific reasoning, and Cultivating interest in science.

Integrated instructional units do not stand alone; they interweave laboratory experiences with other types of science learning activities, including lectures, reading, and discussion. Students form research questions, design and carry out experiments, gather and analyze data, and construct arguments and conclusions as they investigate. Each of the 5 E’s refers to one part of the scientific inquiry process, helping students sequence their learning experiences to construct their understanding of concepts.

Developed by the Biological Sciences Curriculum Study in the 1980's, the 5E Instructional Model is a specific inquiry method for creating integrated instructional units and is a product of reviewing 80 years of research. The hallmark of the Five E’s of inquiry is that students learn science by doing science.

Two essential components of an integrated instructional unit are that:

- Laboratory and other experiences are carefully designed or selected on the basis of what students should learn from them, and
- The experience is explicitly linked to and integrated with other learning activities in the unit.

The Five E’s structure encourages students to understand that different types of questions suggest different types of investigations. When diagnostic, formative assessments are embedded into the instructional sequence, the 5 E’s can be used to gauge each student’s developing understanding and to promote self-reflective thinking. In addition, students come to understand that mathematics and advances in technology contribute to the process of science, and that science advances through legitimate skepticism.

The components of inquiry on this and the facing page are drawn from:  
*The BSCS 5E Instructional Model: Origins, Effectiveness, and Applications.*  

The graphic on the left is taken from the website of Anthony W. Lorsbach at Illinois State University, where it is referred to as a Learning Cycle.
**ENGAGEMENT**

First, students are engaged by an event or question related to the concept that the teacher plans to introduce. They make connections between past and present learning experiences and lay the groundwork for activities to follow. Asking a question, defining a problem or showing a surprising event are all ways to engage students and focus them on the instructional task.

**EXPLORATION**

Students then participate in one or more activities to explore the concept. They have the opportunity to get directly involved with phenomena and materials. This exploration provides students with a common set of experiences which assists them in sharing and communicating and from which they can initiate the development of their understanding. The teacher acts as a facilitator, providing materials and guiding the students’ focus. The students’ inquiry drives the instruction during an exploration.

**EXPLANATION**

In the explain phase, the teacher clarifies the concept and defines relevant vocabulary so that students can put their exploratory experiences into a communicable form. Common language enhances the sharing and communication between teachers and students. Introducing labels after students have had a direct experience is far more meaningful than presenting the terms before the experience.

**EXTENSION** (elaboration)

Students then elaborate on and extend their understanding of the concept by applying it to new situations and making connections to other related concepts. These investigations often lead to further inquiry and new understandings.

**EVALUATION**

Finally, students complete activities that will help them and their teachers evaluate their understanding of the concepts. Diagnostic, formative assessments are embedded into the instructional sequence and can be used to gauge the students’ developing understanding and to promote self-reflection. For example, if the teacher perceives evidence of misconceptions, the activities and concepts can be revisited to enhance clearer understanding. If students show interest in a branching direction of inquiry, the teacher can consider refocusing the investigation to take advantage of that interest. Viewing the evaluation process as a continuous one gives this model a cyclical structure, where questions lead to answers, and then to more questions.
WHAT IS SCIENTIFIC INQUIRY?

SCIENTIFIC INQUIRY STANDARDS

$SIS1$

Make observations, raise questions, and formulate hypotheses.

• Observe the world from a scientific perspective.

• Pose questions and form hypotheses based on personal observations, scientific articles, experiments, and knowledge.

• Read, interpret, and examine the credibility and validity of scientific claims in different sources of information, such as scientific articles, advertisements, or media stories.

We do this every day...whether we know it or not! The goal is to become conscious of our observations, predictions and hypotheses.

$SIS2$

Design and conduct scientific investigations.

• Articulate and explain the major concepts being investigated and the purpose of an investigation.

• Select required materials, equipment, and conditions for conducting an experiment.

• Identify independent and dependent variables.

• Write procedures that are clear and replicable.

• Employ appropriate methods for accurately and consistently:
  - Making observations
  - Making and recording measurements at appropriate levels of precision
  - Collecting data or evidence in an organized way

• Properly use instruments, equipment, and materials (e.g., scales, probeware, meter sticks, microscopes, computers) including set-up, calibration (if required), technique, maintenance, and storage.

• Follow safety guidelines.
### HOW DO STUDENTS KNOW IT AND USE IT?

<table>
<thead>
<tr>
<th>STUDENTS SHOULD KNOW</th>
<th>UNDERSTAND (Essential Questions)</th>
<th>AND BE ABLE TO DO</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ That the basis of ALL learning—not just science—is observing the world around us and questioning what we experience</td>
<td>▶ Why puzzlement is good!</td>
<td>▶ Make a list of different kinds of questions.</td>
</tr>
<tr>
<td>▶ That making predictions based on our observations allows us to collect data to form evidence based hypotheses.</td>
<td>▶ How to problematize “the obvious”</td>
<td>▶ Compare one’s observations of a situation with those of another person or group</td>
</tr>
<tr>
<td>▶ That you can always ask one more question... or can you?</td>
<td>▶ How asking different kinds of questions can result in different kinds of answers</td>
<td>▶ Formulate and test hypotheses</td>
</tr>
<tr>
<td>▶ That the <strong>scientific method</strong> may appear to be a regimented universal system for investigating our world</td>
<td>▶ Why it is important to examine scientific claims</td>
<td>▶ Examine scientific claims in various media</td>
</tr>
<tr>
<td>▶ That the scientific method is actually a creative process used to guide inquiry</td>
<td>▶ Why the scientific method is not a static or strictly sequential process</td>
<td>▶ Design and conduct a scientific investigation using the scientific method.</td>
</tr>
<tr>
<td>▶ That scientists and non-scientists all use “scientific” methods, but scientists tend to be more explicit about the thought processes involved</td>
<td>▶ Why scientists use a structured yet fluid method for inquiry</td>
<td>▶ Create a science journal that details one’s work</td>
</tr>
<tr>
<td>▶ The safety and security guidelines, including guidelines and/or restrictions specific to your program site</td>
<td>▶ How employing scientific methods can help clarify our understanding of any problem</td>
<td>▶ Use equipment and material appropriately, by following safety guidelines</td>
</tr>
<tr>
<td></td>
<td>▶ How safety guidelines protect people</td>
<td></td>
</tr>
</tbody>
</table>
**SIS3**

Analyze and interpret results of scientific investigations.

- Present relationships between and among variables in appropriate forms:
  - Represent data and relationships between and among variables in charts and graphs.
  - Use appropriate technology (e.g., graphing software) and other tools.

- Use mathematical operations to analyze and interpret data results.

- Assess the reliability of data and identify reasons for inconsistent results, such as sources of error or uncontrolled conditions.

- Use results of an experiment to develop a conclusion to an investigation that addresses the initial questions and supports or refutes the stated hypothesis.

**SIS4**

Communicate and apply the results of scientific investigations.

- Develop descriptions of and explanations for scientific concepts that were a focus of one or more investigations.

- Review information, explain statistical analysis, and summarize data collected and analyzed as the result of an investigation.

- Explain diagrams and charts that represent relationships of variables.

- Construct a reasoned argument and respond appropriately to critical comments and questions.

- Use language and vocabulary appropriately, speak clearly and logically, and use appropriate technology (e.g., presentation software) and other tools to present findings.

- Use and refine scientific models that simulate physical processes or phenomena.
**STUDENTS SHOULD KNOW**

- That doing science includes gathering information (also known as data)
- That analyzing and interpreting results of scientific investigations means looking for patterns, as well as breaks in patterns
- That any number of variables can affect results, and changing variables can yield important information

**UNDERSTAND (Essential Questions)**

- That the ways in which we collect data can be just as important as what data we collect
- How one variable, or a great many variables, can affect results
- How analyzing and interpreting results of investigations creates opportunities to perform new experiments

**AND BE ABLE TO DO**

- Collect and represent data through a variety of different means, including graphs and charts
- Identify variables and experiment with changing them
- Analyze and interpret results of investigations using mathematical operations, written exercises, and oral communication
- Revise hypotheses based on collected evidence/data

- Why it is important to communicate the results of investigations clearly, using appropriate scientific language and vocabulary
- How scientific concepts and results of investigations can be communicated through different means
- How applications of scientific inquiries both begin and continue the cycle of scientific investigations

- Apply the results of scientific investigations
- Communicate and discuss scientific concepts that focus on one or more investigations, through written reports, media presentations, lab reports, and/or communities of inquiry
- Explain diagrams/charts that represent relationships of variables
- Use appropriate scientific language and vocabulary
A number of mathematical skills are needed for a solid understanding of science content. Furthermore, **engaging in scientific inquiry often involves the use of mathematics** to analyze and support findings of investigations or the design process.

Most of the math skills listed below are based on standards outlined in the Massachusetts Curriculum Frameworks and in the *DYS Instructional Guide* for teaching math:

- Construct and use tables and graphs to interpret data sets.
- Solve simple algebraic expressions.
- Perform basic statistical procedures to analyze the center and spread of data.
- Measure with accuracy and precision (e.g., length, volume, mass, temperature, time).
- Convert within a unit (e.g., centimeters to meters).
- Use common prefixes such as *milli*-, *centi*-, and *kilo*-.  
- Use scientific notation, where appropriate.
- Use ratio and proportion to solve problems.

Additional specialized mathematical skills that may be needed for teaching and learning science are listed below:

- Determine the correct number of significant figures.
- Determine percent error from experimental and accepted values.
- Use appropriate metric/standard international (SI) units of measurement for mass (kg); length (m); time (s).
- Also, for Physics, use the appropriate units of measurement for force (N); speed (m/s); acceleration (m/s²); frequency (Hz); work and energy (J); power (W); momentum (kg • m/s); electric current (A); electric potential difference/voltage (V); and electric resistance.
- Use the Celsius scale for temperature.
- Also, for Chemistry and/or Physics, use the Kelvin scale for temperature.
Strong lessons and activities always include the 5 E’s. To draw attention to these methods of inquiry, we have used an image of a magnifying glass to emphasize where these inquiries are most explicit throughout this guide.

For more information on the research behind and the effectiveness of the 5E’s, please see *The BSCS 5E Instructional Model: Origins, Effectiveness, and Applications* (Rodger W. Bybee, Joseph A. Taylor, April Gardner, Pamela Van Scotter, Janet Carlson Powell, Anne Westbrook, and Nancy Landes, 2006).

To download PDFs of the full report or summary materials about the 5Es, visit the website below.

http://www.bscs.org/page.asp?pageid=0%7C31%7C95%7C96

Just for fun—a cartoon interpretation of *The Scientific Method*!
In all DYS settings, the primary focus of science instruction is BIOLOGY, which shall be taught through a combination of mini-units, Problems of the Day, and other lessons and instructional strategies, as appropriate to each type of setting. Additionally, SCIENTIFIC INQUIRY SKILLS are essential to good teaching and should be integrated into all science topics and strands.

In instances where students have completed the Biology strand in their previous school, and/or when students were engaged in learning other strands in their previous school, students will require instruction in Chemistry or Physics. A full scope and sequence, as well as curriculum exemplars in Biology, Chemistry, and Introductory Physics, is included in this Instructional Guide.
LEARNING OBJECTIVES

For each strand and emphasized standard, an extended grid outlines what students should KNOW, UNDERSTAND, and be able to DO to demonstrate progress toward specific learning objectives. Primary resources are indicated, and because specialized vocabulary is vital to science learning, important new terminology is highlighted for emphasis.

LESSON PLANNING

The extended KNOW-UNDERSTAND-DO grids are carefully designed to help teachers in all DYS settings develop rigorously standards-based teaching activities. The order of topics in each strand (above) is suggested, but it is not required; the needs of the students and the type of setting will also affect how teachers proceed through each strand.

EXEMPLARS

A set of exemplary curricular materials is provided in this guide. Each exemplar (Mini-Unit, Lesson, and Problem of the Day) is fully elaborated, offering DYS teachers strong models to use in developing and sharing their own teaching materials. A blank template for developing lessons is provided in the Biology section, following the Genetics Mini-Unit and the demonstration lesson. (Look for additional materials to complement this guide on CD.)
<table>
<thead>
<tr>
<th>Key topics in Biology</th>
<th>RELATED STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEMISTRY OF LIFE</td>
<td></td>
</tr>
<tr>
<td>See Chapter 3, Chemistry at the Cellular Level</td>
<td>B 1.2</td>
</tr>
<tr>
<td>B 1.2</td>
<td>Describe the basic molecular structures and primary functions of the four major categories of organic molecules (carbs, lipids, proteins, and nucleic acids).</td>
</tr>
</tbody>
</table>

| CHEMISTRY OF LIFE    |                   |
| See Chapter 3, Chemistry at the Cellular Level, subsection Proteins | B 1.3 |
| B 1.3 | Explain the role of enzymes as catalysts that lower the activation energy of biochemical reactions. Identify factors such as pH and temperature that have an effect on enzymes. |
| See Chapter 6, ATP and Energy Cycles, subsections: Enzymes and Energy Flow, and More About Enzymes |                   |
### Learning Objectives

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<tr>
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<tbody>
<tr>
<td>That <strong>organic molecules</strong> are composed primarily of carbon (C) atoms and other atoms bonded together, and the most common elements in organic molecules are C, H, N, O, P, and S (refer to Standard B 1.1)</td>
<td>Why we study chemistry in a biology course</td>
<td>Create a brochure describing the functions and structures of each type of macromolecule</td>
</tr>
<tr>
<td>That the four large organic molecules—also called <strong>macromolecules</strong>—are <strong>carbohydrates, lipids, proteins, and nucleic acids</strong>, and all biological organisms are composed of these</td>
<td>That all living things have similar complex organic molecules called macromolecules that help to carry out the basic activities of life</td>
<td>Provide similarities and differences between carbohydrates, lipids, proteins, and nucleic acids using a Venn diagram</td>
</tr>
<tr>
<td>The basic structure and function of carbohydrates, lipids, proteins, and nucleic acids</td>
<td></td>
<td>Review food labels to identify ingredients that represent the four macromolecules essential for healthy nutritional balance.</td>
</tr>
<tr>
<td>That enzymes are a type of protein, and play an important role in <strong>chemical reactions</strong> that are important to sustain life</td>
<td>That enzymes play an important role in maintaining good health</td>
<td>Identify various examples of enzymes in the human body and the chemical reactions they help to facilitate (e.g., the enzyme lactase that breaks down the sugar, lactose, found in dairy products)</td>
</tr>
<tr>
<td>That enzymes can stop a chemical reaction or speed up a chemical reaction by acting as a <strong>catalyst</strong></td>
<td>That environmental factors such as pH and temperature have a direct affect on an enzyme’s ability to do its job</td>
<td>Describe, in general, how factors such as pH and temperature can affect an enzyme’s ability to start or stop a chemical reaction</td>
</tr>
<tr>
<td>That enzymes act by breaking chemical bonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>That enzymes work as catalysts by lowering the <strong>activation energy</strong> needed to activate or begin certain chemical reactions, and that this breaks the bonds of the reactants which are needed to begin the reaction</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Key topics in Biology

#### RELATED STANDARDS

**CELL BIOLOGY:**
**CELL PARTS AND FUNCTIONS**

In Chapter 4, see subsections *Cell Structure and Function* and *What Kind of Cell Is It?*

Also see Chapter 5, *A Journey into the Eukaryotic Cell*

---

**B 2.1**

Relate cell parts/organelles (plasma membrane, nuclear envelope, nucleus, nucleolus, cytoplasm, mitochondrion, endoplasmic reticulum, Golgi apparatus, lysosome, ribosome, vacuole, cell wall, chloroplast, cytoskeleton, centriole, cilium, flagellum, pseudopod) to their functions. Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, facilitated diffusion, active transport).

**LS 3, 4**
Learning Objectives

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>▶ That the cell <strong>parts/organelles</strong> found in <strong>eukaryotic</strong> cells relate to the function of each part (refer to Standard B 2.2)</td>
<td>▶ That eukaryotic cells are more structurally complex than <strong>prokaryotic</strong> cells (refer to Standard B 2.2)</td>
<td>▶ Relate cell organelles to organs in the human body in regard to their functions/jobs</td>
</tr>
<tr>
<td>▶ That plant and animal cells mostly have the same cell parts; however, plant cells also have organelles such as chloroplasts to obtain energy and cell walls for structure and protection</td>
<td>▶ That just as the human body has organs such as the heart and the brain which do important jobs for the body, cells have particular cell parts called organelles that do important jobs for the cell</td>
<td>▶ Compare the organelles in a eukaryotic cell to the different people and/or departments in a factory or school based on their functions/jobs</td>
</tr>
<tr>
<td>▶ That the composition of the cell membrane makes it a <strong>highly selective barrier</strong>, allowing only certain chemicals to move through it, while keeping others from passing</td>
<td>▶ That proper functioning of the cell’s organelles is important for the cell’s survival</td>
<td>▶ Identify the similarities and differences between the organelles found in a plant cell, and the organelles found in an animal cell</td>
</tr>
</tbody>
</table>
| ▶ The difference between:  
  • **Diffusion**  
  • **Osmosis**  
  • Facilitated diffusion  
  • Active transport | ▶ That although they are similar, different types of cells have different organelles to help fulfill different needs for survival e.g., prokaryote vs. eukaryote, plant vs. animal) | ▶ Create a story describing the process of diffusion and/or osmosis from the perspective of either the cell membrane or the particles involved |
| ▶ The importance of the cell membrane as a highly selective barrier in maintaining **homeostasis** or balance within the cell | ▶ The importance of the cell membrane as a highly selective barrier in maintaining **homeostasis** or balance within the cell | ▶ Identify examples of diffusion, osmosis, facilitated diffusion, and active transport |
### Key topics in Biology

<table>
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</thead>
</table>

**CELL BIOLOGY:**

**CELLULAR RESPIRATION & PHOTOSYNTHESIS**

For review, see Chapter 5, subsection on *Bonding Patterns* for information on reactants / products.

In Chapter 6, see subsection *Making ATP*.

In Chapter 7, see subsections *What Is Cellular Respiration?* and *The Stages of Cellular Respiration*.

In Chapter 8, see subsection *What is Photosynthesis?*

---

**B 2.4**

Identify the reactants, products and basic purposes of photosynthesis and cellular respiration. Explain the interrelated nature of photosynthesis and cellular respiration in the cells of photosynthetic organisms.

**LS 4, 16**
# Learning Objectives

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>▶ The important role that ATP serves in both cellular respiration and photosynthesis (refer to Standard B 2.5).</td>
<td>▶ That cells perform chemical reactions such as those involved in cellular respiration to gain energy which is stored in the cell in the form of ATP</td>
<td>▶ Compare and contrast photosynthesis and cellular respiration.</td>
</tr>
<tr>
<td>▶ What the reactants (what goes in) and products (what comes out) of a chemical reaction are of each process.</td>
<td>▶ That all living things need energy, and this energy is produced by every cell through the process of cellular respiration</td>
<td>▶ Identify the reactants and products of each process.</td>
</tr>
<tr>
<td>▶ Basic reactants of photosynthesis:</td>
<td>▶ That in both photosynthesis and cellular respiration, the reactants undergo multiple chemical reactions before the final products are produced</td>
<td>▶ Explain how the process of photosynthesis and cellular respiration is interconnected in photosynthetic organisms.</td>
</tr>
<tr>
<td>• Carbon dioxide</td>
<td>▶ That in photosynthetic organisms such as plants, photosynthesis and cellular respiration occur simultaneously; photosynthesis produces glucose which is then broken down to make energy through the process of cellular respiration</td>
<td>• For example, why does a plant need to make its own glucose (food) whereas an animal does not?</td>
</tr>
<tr>
<td>• Water</td>
<td>▶ Basic products of photosynthesis:</td>
<td>▶ Explain the importance of photosynthesis and cellular respiration in relation to the cell’s need for energy.</td>
</tr>
<tr>
<td>• Energy (in the form of sunlight)</td>
<td>• Glucose (a type of sugar)</td>
<td>▶ Illustrate the “cycle” of energy flow between two organisms or within a photosynthetic organism.</td>
</tr>
<tr>
<td>▶ Basic products of photosynthesis:</td>
<td>▶ Basic reactants of cellular respiration:</td>
<td></td>
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<tr>
<td>• Glucose</td>
<td>• Glucose</td>
<td></td>
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<tr>
<td>• Oxygen</td>
<td>• Oxygen</td>
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<tr>
<td>• Water</td>
<td>▶ Basic products of cellular respiration:</td>
<td></td>
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<tr>
<td></td>
<td>• Carbon dioxide</td>
<td></td>
</tr>
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<td></td>
<td>• Water</td>
<td></td>
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<tr>
<td></td>
<td>• Energy (in the form of ATP)</td>
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</tbody>
</table>
**CELL BIOLOGY**

In Chapter 9, see subsections *The Cell Cycle and Mitosis* and *What is Cancer*?

**RELATED STANDARDS**

<table>
<thead>
<tr>
<th>B 2.6</th>
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<tbody>
<tr>
<td>Describe the cell cycle and the process of mitosis. Explain the role of mitosis in the formation of new cells, and its importance in maintaining chromosome number during asexual reproduction.</td>
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<thead>
<tr>
<th>LS 9</th>
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</table>
## Learning Objectives

<table>
<thead>
<tr>
<th>STUDENTS SHOULD KNOW</th>
<th>UNDERSTAND (Essential Questions)</th>
<th>AND BE ABLE TO DO</th>
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</thead>
</table>
| ▶ That the **cell cycle** is composed of 2 phases:  
  • **Interphase**  
  • **Mitosis** | ▶ The importance of the DNA instructions found in the chromosomes of a cell, and why it is crucial for identical copies of these instructions to be made and distributed between the two new daughter cells | ▶ Identify graphic representations of each phase of mitosis. For example, a microscopic view or drawing of metaphase versus telophase |
| ▶ That mitosis has four sequential phases:  
  • **Prophase** (Preparation to divide)  
  • **Metaphase** (Lining up chromosomes in the **M**iddle)  
  • **Anaphase** (Chromosomes move **A**part)  
  • **Telophase** (Two identical cells are formed) | ▶ That the cell cycle and mitosis play an important role in cell reproduction, growth of the organism, and repair/maintenance of the organism | ▶ Discuss the general process of the cell cycle and explain its importance in maintaining chromosome number during asexual reproduction |
| ▶ That the cell cycle organizes and separates copies of **chromosomes** in a **parent cell** into two identical **daughter cells** in order to make an identical copy of the parent cell. | ▶ That when the cell cycle is not controlled properly, a cell will grow and divide too much, resulting in a condition called **cancer** | ▶ Construct models of each phase of the cell cycle using paper, clay, popsicle sticks, etc. |
| ▶ That the cell cycle is a form of **asexual reproduction**, and the purpose of the cell cycle is to reproduce copies of a cell that are identical in structure and chromosome number | | ▶ Provide examples of when it is necessary for the cell cycle to make new cells; for example, in healing a cut on one’s finger |
| | | ▶ Investigate recent theories on cancer and how problems with the cell cycle may be involved |
## Key topics in Biology

<table>
<thead>
<tr>
<th>RELATED STANDARDS</th>
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<tbody>
<tr>
<td><strong>CELL BIOLOGY</strong></td>
</tr>
<tr>
<td>In Chapter 9, see subsections <em>Meiosis: The Life Cycle of Sex Cells</em> and <em>The Human Reproductive System</em></td>
</tr>
</tbody>
</table>

**B 2.7**

Describe how the process of meiosis results in the formation of haploid cells. Explain the importance of this process in sexual reproduction, and how gametes form diploid zygotes in the process of fertilization.

**LS 9**
### Learning Objectives

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</table>
| ▶ That unlike mitosis, **meiosis** produces haploid daughter cells with half the number of chromosomes of the parent cell | ▶ That the purpose of meiosis is to produce gametes that have half the amount of genetic information as the original cell; thus, when two haploid gametes combine, the resulting zygote has the accurate number of chromosomes:  
• For example, human eggs have 23 chromosomes and human sperm each carries 23 chromosomes, so when fertilization occurs, the zygote has a combined number of 46 chromosomes (a set of 23 from each parent) | ▶ Discuss how the general process of meiosis results in the formation of haploid cells. Explain why this is an important step in sexual reproduction:  
• Explain the importance of meiosis in creating sex cells (or gametes) |
| ▶ That haploid cells are also called **gametes** (or sex cells) | ▶ The importance of this process in the reproduction of a new organism | ▶ Construct models of each phase of meiosis I and meiosis II using paper, clay, popsicle sticks, etc. |
| ▶ That meiosis is important in **sexual reproduction**:  
• A haploid egg (female gamete) joins with a haploid sperm (male gamete) during a process called **fertilization**, forming a diploid cell, called a **zygote** | | ▶ Investigate disorders and/or diseases that may result when there are problems with meiosis:  
• Create an informative brochure explaining what happened during the process of meiosis that resulted in the condition |
| ▶ That meiosis is broken into two parts: **Meiosis I** and **Meiosis II**:  
• **Meiosis I** organizes and separates copies of chromosomes into two daughter cells, and  
• **Meiosis II** further organizes the remaining chromosomes in the two daughter cells and separates them into two more daughter cells | | ▶ Compare and contrast the process of mitosis and meiosis using illustrations or a Venn diagram, including differences in the cells resulting from each type of division |
<table>
<thead>
<tr>
<th>Key topics in Biology</th>
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<tbody>
<tr>
<td><strong>GENETICS</strong></td>
<td></td>
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<tr>
<td>In Chapter 11, see subsections <em>How Are Molecules of Life Involved in Heredity?</em>, <em>DNA Replication</em>, and <em>The Path of Genetic Information</em></td>
<td></td>
</tr>
<tr>
<td>In Chapter 5, see subsection <em>Information Organelles</em></td>
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<tr>
<td><strong>B 3.2</strong></td>
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<tr>
<td>Describe the basic process of DNA replication and how it relates to transmission and conservation of the genetic code. Explain the basic processes of transcription and translation, and how they result in the expression of genes. Distinguish among the end products of replication, transcription, and translation.</td>
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<td><strong>LS 7, 8</strong></td>
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# Learning Objectives

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| - That hereditary information is contained in **chromosomes**, which are made up of genes (refer to Standard B 3.1)  
  - Genes are comprised of unique sequences of **DNA** specific to each organism | - That DNA carries unique genetic information which is passed on from parent to offspring (refer to Standard B 3.1)  
  - Why the structure of DNA and RNA is important to the processes of replication and the making of proteins  
  - How DNA replicates to produce new cells, thus transmitting and preserving the genetic code  
  - That protein synthesis will occur when a specific protein is needed by the organism  
  - That the DNA found in genes holds the “directions” for making specific proteins | - Identify the basic structure and major components of DNA in a diagram (Refer to Standard B 3.1)  
  - Construct a model of DNA using paper, clay, beads and wire, etc.  
  - Tell the story of DNA replication, verbally or in writing, from the perspective of the DNA. Discuss the importance of this process  
  - Be sure to explain complementary DNA base pairs in replication  
  - Model the process of replication and/or protein synthesis with clay or paper cutouts  
  - Construct a flow chart showing the basic process of protein synthesis; discuss the importance of this process  
  - Discuss complementary RNA base pairs to a given DNA template  
  - Explain the role of mRNA and tRNA when matching codons and anticodons (More advanced)  
  - Use a Venn Diagram to compare and contrast:  
    - the structures and functions of DNA and RNA  
    - the end products of replication, transcription, and translation |
### Key topics in Biology

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In Chapter 11, see subsection *The Path of Genetic Information*

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<th><strong>B 3.3</strong></th>
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Explain how *mutations* in the DNA sequence of a gene may or may not result in *phenotypic* change in an organism. Explain how mutations in *gametes* may result in phenotypic changes in offspring.
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<tbody>
<tr>
<td>Some external or internal causes of mutation</td>
<td>Why mutations can result if a DNA strand or code is not copied correctly</td>
<td>Explain how a mutation can occur due to external or internal causes</td>
</tr>
<tr>
<td>That mutation is a change in a DNA sequence</td>
<td>How a mutation during replication means that a parent cell will not pass on the exact genetic information carried on the parent’s DNA</td>
<td>Predict, verbally or in writing, how an error in a sequence of DNA will result in the incorrect protein or no protein being made</td>
</tr>
<tr>
<td>That a mutation in a body cell does not get passed on to offspring, but a mutation in a gamete (sex cell) can be passed on to offspring</td>
<td>How a mutation during protein synthesis can result in the production of no protein or an incorrect protein</td>
<td>Research examples of disorders that can result from an error in the translation of the code</td>
</tr>
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<td></td>
<td>Why mutations increase the genetic variation of a population</td>
<td>Explain that some mutations result in phenotypic change, while others do not <em>(More advanced)</em></td>
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</table>
### WHAT BIOLOGY SHOULD STUDENTS KNOW?

<table>
<thead>
<tr>
<th>Key topics in Biology</th>
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<tbody>
<tr>
<td><strong>GENETICS</strong></td>
<td><strong>B 3.4</strong></td>
</tr>
<tr>
<td>In Chapter 10, see subsections <em>What Did Mendel Discover?</em> and <em>Different Ways Alleles Cooperate</em></td>
<td>Distinguish among observed inheritance patterns caused by several types of genetic traits (<a href="#">dominant</a>, <a href="#">recessive</a>, <a href="#">codominant</a>, <a href="#">sex-linked</a>, <a href="#">polygenic</a>, <a href="#">incomplete dominance</a>, <a href="#">multiple alleles</a>).</td>
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</table>
## Learning Objectives

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<tbody>
<tr>
<td>‣ How to use a <strong>Punnett Square</strong> to determine the probabilities for <strong>genotype</strong> and <strong>phenotype</strong> combinations in monohybrid crosses (refer to Standard B 3.6)</td>
<td>‣ That a Punnett Square determines the probabilities for genotype and phenotype combinations in monohybrid crosses (refer to Standard B 3.6)</td>
<td>‣ Create a poster explaining Mendel’s Law of Dominance, including descriptions and examples of: • dominant and recessive • genotype and phenotype • heterozygous and homozygous</td>
</tr>
<tr>
<td>‣ Mendel’s <strong>Law of Dominance</strong></td>
<td>‣ That characteristics of an organism can be determined by these patterns of inheritance</td>
<td>‣ Use Punnett Squares to solve monohybrid cross practice problems. Analyze the results of the cross to identify phenotype and genotype ratios of offspring</td>
</tr>
<tr>
<td>‣ The potentially different phenotypic outcomes between <strong>homozygous</strong> and <strong>heterozygous</strong> genotypes in different inheritance patterns</td>
<td>‣ That genetic screening enables potential parents to know the likelihood that their children will inherit particular conditions</td>
<td>‣ Interpret a pedigree chart • Identify males, females, and individuals expressing recessive traits • Identify parental genotypes when offspring phenotypes are given (More advanced)</td>
</tr>
<tr>
<td>‣ That pedigree charts are a way of visually representing biological inheritance</td>
<td></td>
<td>‣ Use Punnett Squares to solve crosses involving codominance, sex-linkage, polygenic inheritance, incomplete dominance, and multiple alleles (More advanced)</td>
</tr>
</tbody>
</table>
### Key topics in Biology

**GENETICS**

In Chapter 10, see subsections *What Did Mendel Discover?* and *Different Ways Alleles Cooperate*

### RELATED STANDARDS

**B 3.5**

Describe how Mendel’s **laws of segregation** and **independent assortment** can be observed through patterns of inheritance (e.g., dihybrid crosses).
# Learning Objectives

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</table>
| ♦ Mendel’s Law of Segregation  
  • That segregation occurs during meiosis and results in each gamete receiving one allele | ♦ How Mendel’s Law of Segregation explains why sex cells have only one allele for a trait  
  ♦ That examining the F<sub>1</sub> and F<sub>2</sub> generations for particular genetic crosses can provide evidence for Mendel’s Law of Segregation  
  ♦ How the Law of Independent Assortment provides an explanation for why most traits are not inherited together | ♦ Pretending that they are animal breeders, describe animals in relation to each other using the terms P, F<sub>1</sub> and F<sub>2</sub> generations  
  ♦ Predict allele combinations in gametes produced for 2 different traits  
  • For example, for traits Tt and Gg, a gamete could have any of the following allele combinations: TG, Tg, tG, and tg  
  ♦ Explain that **homologous chromosomes** separate during meiosis, when sex cells are formed (**More advanced**)  
  ♦ Solve dihybrid crosses using Punnett Squares (**More advanced**)  
  • Interpret the problem in order to write the parental cross correctly (**More advanced**) |
## WHAT BIOLOGY SHOULD STUDENTS KNOW?

<table>
<thead>
<tr>
<th>Key topics in Biology</th>
<th>RELATED STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANATOMY AND PHYSIOLOGY</strong></td>
<td></td>
</tr>
<tr>
<td>In Chapter 4, see subsections <em>Cellular Structure and Function</em>, and <em>After the Cell</em></td>
<td></td>
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<tr>
<td>Also see Chapter 12, <em>Human Body Systems</em></td>
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<tr>
<td><strong>B 4.8</strong></td>
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</tr>
<tr>
<td>Recognize that the body’s systems interact to maintain <a href="https://www.dictionary.com/browse/homeostasis">homeostasis</a>. Describe the basic function of a <a href="https://www.dictionary.com/browse/physiological-feedback-loop">physiological feedback loop</a>.</td>
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<tr>
<td><strong>LS 5, 6</strong></td>
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</table>
# Learning Objectives

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<tbody>
<tr>
<td>‣ That the major systems of the human body interact to maintain homeostasis. More generally, the functions and organs of the major systems of the human body (refer to Anatomy &amp; Physiology Standards B 4.1-4.7)</td>
<td>‣ That living systems operate within specific <strong>optimal ranges</strong>, for example, that a human’s internal temperature is ~ 98.6º F</td>
<td>‣ Explain how homeostasis is maintained at different levels of hierarchical organization in multicellular organisms; focus on one body system as an example</td>
</tr>
</tbody>
</table>
| ‣ The hierarchical organization of multicellular organisms (cells, tissues, organs, organ systems, organisms) | ‣ That environmental and internal factors act as **stressors** on the body  
  • When this occurs, the body systems will react to reestablish balance | ‣ Create a comic strip or story describing the process of homeostasis for a specific body system, including  
  • environmental and internal stressors  
  • physiological feedback loop  
  • the body’s response to restore balance within that body system |
| ‣ That feedback loops signal the body when something is out of balance, and when balance has been reestablished | ‣ That organisms that cannot reestablish homeostasis will die without medical intervention | ‣ Write a children’s book describing an example of 2 or more human systems interacting in a homeostatic response |

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**HOW DO WE KNOW THAT THEY KNOW IT?**
### Key topics in Biology

<table>
<thead>
<tr>
<th>EVOLUTION AND BIODIVERSITY</th>
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<tbody>
<tr>
<td>In Chapter 13, see subsections <em>Evidence of Evolution</em> and <em>Natural Selection</em></td>
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**B 5.1**

Explain how evolution is demonstrated by evidence from the fossil record, comparative anatomy, genetics, molecular biology, and examples of natural selection.

**LS 11**
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</table>
| ‣ That the fossil record, comparative anatomy, molecular biology, genetics, and examples of natural selection provide evidence for the **theory of evolution** | ‣ How scientific evidence supports the theory of evolution  
 ‣ Why the occurrence of natural selection is observable today | ‣ Infer relative age of fossils and relationships to other known organisms given a diagram of geologic strata or fossil foot prints  
 ‣ Tell the story of the last plant or animal of a species that was alive in the past and is now extinct  
 ‣ Interpret a diagram to identify homologous structures as providing evidence of common ancestry between organisms  
 • For example, compare structures from different animals such as the wing of a bird, the flipper of a whale, and the arm of a human  
 ‣ Distinguish homologous structures from analogous structures *(More advanced)*  
 ‣ Compare data from different species (for example, amino acid sequences from a worm, a chimp, and a human) to identify which are most closely related *(More advanced)* |
Key topics in Biology

EVOLUTION AND BIODIVERSITY

In Chapter 14, see subsections *What is Speciation?*, *Classifying Species*, and *Conditions for Speciation to Occur*

Also see Chapter 15, *Phylogenies and Classifying Diversity*

B 5.2
Describe species as reproductively distinct groups of organisms. Recognize that species are further classified into a hierarchical taxonomic system—*Kingdom, Phylum, Class, Order, Family, Genus, Species*—based on morphological, behavioral, and molecular similarities. Describe the role that geographic isolation can play in speciation.

LS 1
## Learning Objectives

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<tbody>
<tr>
<td>▶ That all organisms are classified into 3 <strong>Domains</strong></td>
<td>▶ Basic similarities shared by living things</td>
<td>▶ Compare and contrast the Kingdoms on the basis of cell structure, cell number, and modes of nutrition (refer to Standard B 2.3)</td>
</tr>
<tr>
<td>▶ That species are reproductively distinct groups of organisms</td>
<td>▶ Why it is important and useful for biologists to classify organisms</td>
<td>▶ When given key characteristics of an organism, correctly classify it into the proper Kingdom</td>
</tr>
<tr>
<td>▶ That every species of organism is further classified into a hierarchical taxonomic system below the Domain level (Kingdom, Phylum, Class, Order, Family, Genus, Species)</td>
<td>▶ Why Latin is used in taxonomic classification</td>
<td>▶ Design a game of Memory using index cards. Place pictures or descriptions of representative organisms on half the cards, and the corresponding Kingdom for each on the others.</td>
</tr>
<tr>
<td>▶ That these classification levels are based upon <strong>morphological</strong>, behavioral, and molecular similarities</td>
<td></td>
<td>▶ Presented with the Latin name, be able to distinguish genus from species</td>
</tr>
<tr>
<td>▶ Common examples of each kingdom</td>
<td></td>
<td>▶ Describe how speciation can occur following the geographic isolation of members of an existing species</td>
</tr>
<tr>
<td>▶ That each species is identified by two Latin names, the genus and species</td>
<td></td>
<td>▶ Using a <strong>phylogenetic</strong> tree, recognize morphological, behavioral, and/or molecular similarities shared by members of a specific taxonomic group <em>(More advanced)</em></td>
</tr>
<tr>
<td>▶ That new species can arise when geographic isolation is followed by <strong>reproductive isolation</strong></td>
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</table>
### Key topics in Biology

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<th>EVOLUTION AND BIODIVERSITY</th>
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<tbody>
<tr>
<td>In Chapter 13, see subsections <em>What is Biological Evolution?</em>, <em>Processes in Evolution</em> and <em>Natural Selection</em></td>
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<tr>
<td><strong>B 5.3</strong></td>
</tr>
<tr>
<td>Explain how <em>evolution</em> through <em>natural selection</em> can result in changes in <em>biodiversity</em> through the increase or decrease of genetic diversity within a population.</td>
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| LS 10, 18 |
# Learning Objectives

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| ‣ That genetic variation and environmental factors are causes of evolution | ‣ That organisms cannot develop survival adaptations at will; these features occur through genetic variation | ‣ Discuss how the components of Darwin’s theory of natural selection impact the diversity of life  
• For example, natural selection, and “survival of the fittest” |
| ‣ That biological evolution accounts for the diversity of all living things | ‣ That modern evolutionary theory combines Darwin’s ideas with information about genetic inheritance | ‣ Research examples of adaptations to one’s environment, such as camouflage, and present them in a poster, book, or PowerPoint slideshow |
| ‣ How natural selection and adaptations can allow certain organisms to survive and reproduce | ‣ That when genetic diversity within a population changes due to natural selection, changes in biodiversity result | ‣ Given an example of an environmental factor that would impact the survival of an organism, brainstorm genetic variations that would give some organisms a competitive advantage to survive  
• For example, if the annual temperature decreased, polar bears with a thicker layer of blubber than others in their population would be more fit to survive. |

Explain that changes in genetic diversity in a population can occur due to the **Founder Effect** or **bottleneck effect** *(More advanced)*
WHAT BIOLOGY SHOULD STUDENTS KNOW?

**ECOLOGY**

In Chapter 17, see subsection *Relationships in Communities*; in Chapter 18, see subsection *How Does Energy Flow Through Ecosystems?*

**B 6.3**

Use a food web to identify and distinguish *producers, consumers*, and *decomposers*, and explain the transfer of energy through *trophic levels*. Describe how relationships among organisms (predation, parasitism, competition, commensalism, mutualism) add to the complexity of biological communities.

**LS 13, 14**
# Learning Objectives

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<tbody>
<tr>
<td>▶ The roles and relationships among producers, consumers, and decomposers in a food chain or food web</td>
<td>▶ That the sun is the original source of energy for a food chain</td>
<td>▶ State the ecological roles of producers, consumers, and decomposers in food webs</td>
</tr>
<tr>
<td>▶ How energy flows through a food chain or web within a habitat and/or ecosystem</td>
<td>▶ Why producers are the base of every food chain</td>
<td>▶ Predict, verbally or in writing, what would happen to members of trophic levels if the members of another trophic level died off</td>
</tr>
<tr>
<td>▶ How to read a diagram of a food web or food chain</td>
<td>▶ That energy transferred decreases at each successive level of a food chain</td>
<td>▶ Research examples of symbiosis, either positive (mutualistic) relationships or negative (e.g., parasitic) relationships between organisms</td>
</tr>
<tr>
<td>▶ That biological communities include organisms in varying relationships to each other (predation, parasitism, competition, commensalism, and mutualism)</td>
<td>▶ That symbiotic relationships between organisms in a community generally relate to an organism’s either obtaining food, or avoiding becoming food for another organism</td>
<td>▶ Design a children’s book explaining one of these examples</td>
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</table>

- Construct and interpret diagrams of food webs or chains
  - Identify organisms at each trophic level as producer, primary consumer, secondary consumer, and higher-order consumer
  - Identify the percent energy reduction at each level of the food pyramid (More advanced)

- Identify the percent energy reduction at each level of the food pyramid (More advanced)

- Identify a relationship between two organisms as predatory, parasitic, competitive, commensal, or mutualistic (More advanced)
ECOLOGY

In Chapter 18, see subsection *The Cycling of Chemicals in an Ecosystem*

**B 6.4**

Explain how water, carbon, and nitrogen cycle between **abiotic resources** and **organic matter** in an ecosystem, and how oxygen cycles through photosynthesis and respiration.

**LS 15**
### Learning Objectives

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<tbody>
<tr>
<td>‣ That water, carbon, nitrogen, and oxygen are needed to support life</td>
<td>‣ Why it is important that matter is <em>conserved</em> in ecosystems</td>
<td>‣ Summarize the steps of the water, carbon, nitrogen, and oxygen cycles</td>
</tr>
</tbody>
</table>
| ‣ The basic steps and importance of each:  
  • the water cycle  
  • the carbon cycle  
  • the nitrogen cycle  
  • the oxygen cycle | ‣ That photosynthesis and respiration are *complementary* processes | ‣ Plan and act out a skit demonstrating the steps of the cycles |
| ‣ How matter cycles through an ecosystem, and the role that decomposers play in this cycling | | ‣ Create diagrams of each cycle |
| | | ‣ Utilize a graphic organizer to outline steps of each cycle |
| | | ‣ Cite an example of decomposers contributing to the cycling of matter by breaking down dead plants and animals |
| | | ‣ Write a creative paragraph about life without decomposers |
| | | ‣ Orally, in writing, or using graphics, show the connection between photosynthesis and respiration |
By the end of this mini-unit, students should:

- Definitions for key terms:
  - genetic trait
  - Mendel’s Law of Dominance
  - dominant
  - recessive
  - phenotype
  - genotype
  - monohybrid cross
  - probability
  - allele
  - heterozygous (hybrid)
  - homozygous (pure)
  - pedigree chart
  - P₁, F₁, and F₂ generations

- That a Punnett Square determines the probabilities for genotype and phenotype combinations in monohybrid crosses (refer to Standard B 3.6)

- The potentially different phenotypic outcomes between homozygous and heterozygous genotypes in different inheritance patterns

- That some genetic crosses do not follow the rules of simple dominance
Characteristics of an organism can be determined by these various patterns of inheritance.

That the Punnett Square is a tool used to predict the probability (not certainty) of producing offspring with particular characteristics, based upon given parental genotypes (refer to Standard B 3.6).

That pedigree charts are a way to visually represent biological inheritance.

That genetic screening enables potential parents to know the likelihood that their children will inherit particular conditions.

That variations on dominant/recessive inheritance include sex-linkage, codominance, multiple alleles, incomplete dominance, and polygenic inheritance across generations.

That sex cells have only one allele for a trait.

That examining the phenotypes of offspring in a pedigree chart can make it possible to identify the genotype of a parent or a child.

**Lesson 1:**

Predict the percent chance of producing a female or male child by performing simple probability problems (Example) Students carry out coin tosses to predict the percent change of producing a female or male child.

(Note: Lesson 1 is presented as a fully-developed exemplar in the pages following this mini-unit.)
Lesson 2:
- Create a poster explaining Mendel’s Law of Dominance, including descriptions and examples of:
  - Dominant and recessive traits
  - Genotype and phenotype
  - Heterozygous and homozygous genotypes
- Use Punnett Squares to solve monohybrid cross practice problems
  - Analyze the results of the cross to identify phenotype and genotype ratios of offspring

Lesson 3:
- Use Punnett Squares to solve monohybrid cross practice problems involving Mendel’s Law of Dominance as well as codominance and incomplete dominance
  - Analyze the results of the cross to identify phenotype and genotype ratios of offspring

Lesson 4:
- Given the genotypes of parents, predict the potential genotypes of their offspring
  (Example) Examining magazine photos of the faces of 2 adults, and given information on which features are dominant, students compare several facial features that are inherited by simple dominance, toss coins to simulate possible crosses, and predict which facial features a child of these 2 parents would inherit
- Demonstrate understanding of basic inheritance patterns by solving monohybrid cross word problems or completing an activity such as “Variations on a Human Face Lab”

Lesson 5:
- Use Punnett Squares to solve monohybrid cross practice problems involving multiple alleles (i.e., ABO blood types)
- Demonstrate understanding of basic inheritance patterns by solving monohybrid cross word problems or mystery scenarios involving examples of multiple alleles
Learning objectives in this mini-unit are tied to the following:

**Lesson 6:**
- Identify males, females, and individuals expressing recessive traits from a pedigree chart
  (Example) Utilizing five simple dominant/recessive traits supplied by the teacher, students create a pedigree chart poster for an imaginary family; pedigree chart must follow the laws of biological inheritance
- Interpret a pedigree chart to identify parental genotypes when offspring phenotypes are given
  (Example) Examining a pedigree chart using shading to represent blue eyes, student work backwards to identify whether the parents of children with blue and brown eyes are heterozygous or homozygous for eye color

**Lesson 7:** (Culminating)
Ideally, a variety of assessment tools should be used. Students must demonstrate ability to solve problems by Punnett Squares, and to interpret a pedigree chart, so the teacher should come prepared with problems of this sort.

- Other means of assessment might include:
  - A role play in which a couple seeks genetic counseling and is advised about how a particular illness is inherited, and what the percent probability is of their child having the condition
  - The construction of a pedigree chart poster for an imaginary family, utilizing three simple dominant/recessive traits supplied by the teacher. Chart must follow the laws of biological inheritance.
  - A quiz game modeled on *JEOPARDY!* where students can pair up to answer review questions

- Apply understanding of inheritance to solve Punnett squares involving sex-linked and/or polygenic traits (may include dihybrid crosses)
  (Example) Given genotypes, students correctly match a colorblind child with his/her potential biological parents (sex-linked)

**More Advanced Extensions of Learning**
MINI-UNIT: MENDELIAN GENETICS (continued)

LEARNING STANDARDS

B 3.1
Describe the function of DNA in genetic inheritance (review from previous units)

B 3.4 (Emphasized Standard)
Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, co-dominant, sex-linked, polygenic, incomplete dominance, multiple alleles)

B 3.6
Use a Punnett Square to determine the probabilities for genotype and phenotype combinations in monohybrid crosses

Mathematical Skills
Use ratio and proportion to solve problems

PRE-ASSESSMENT

Oral survey, or matching or diagram game, that draws on students’ prior knowledge of DNA and meiosis from the preceding unit

Discussion or journaling describing physical “traits” or characteristics that students have observed in daily life among family members, pets, etc.

MATERIALS
(Note: while this is a good overall materials list, it is possible that you will need more or different objects as you proceed through this mini-unit)

- Coins, masking tape, and glue (if permitted)
- Photocopied handouts of Exercise 48 from Biology: Cycles of Life Lab Manual, “Probability of Gender”
- Calculators (optional, but helpful)
- Paper and pencil
- Index cards
- Problem sets for Punnett squares, probability problems, and pedigrees
- A mirror, if permitted (can be plastic)
- Magazines with pictures of facial features
- Visual depiction of facial features, showing phenotypes and genotypes
- Copies of handouts: Variations of the Human Face Lab
- PTC paper (optional, only if permitted)
- Map pencils, markers, or other coloring supplies (optional) NOTE: Crayola offers a "My World Colors" set for various skin tones and eye colors

Genetics student tutorial on the basics, plus practice quizzes:

[http://anthro.palomar.edu/mendel/mendel_1.htm](http://anthro.palomar.edu/mendel/mendel_1.htm)

Links to student tutorials on Mendel (wordy; but useful for visuals of how pea plants differ), Punnett Squares, and genetic problems on blood type/parenthood:

[http://www.cccoe.net/genetics/student.html](http://www.cccoe.net/genetics/student.html)

Genetics problem sets, to practice setting up and solving Punnett Squares; a variety of problems, but no visuals as cues for students:

[http://library.thinkquest.org/C004367/be1a.shtml](http://library.thinkquest.org/C004367/be1a.shtml)

Variations of the Human Face Lab:

Use coins, a mirror, a photograph, and sketches of facial features to determine how a child of yours might inherit some, but not all, of your facial features; the website offers handouts of the face lab:

Resource for explanation and practice problems involving variations on Mendel’s Law of Dominance:

http://users.adelphia.net/~lubehawk/BioHELP/multalle.htm

Blood Types Tutorial by The Biology Project:


Alternative to the Variation on the human face activity using animal parts instead of human (see Handout 5 in particular):


Alternative activities similar to the Variations on a Human Face Lab:

http://www.kumc.edu/gec/lpweiss.html

An interactive activity including pedigree questions and Queen Victoria’s sex-linkage and hemophilia story:

http://www.galeschools.com/lesson_plans/secondary/math/genetics.htm

For a karyotyping activity (more advanced work), students match chromosome pairs, and then identify genetic disorders revealed by the completed karyotype:

http://www.biology.arizona.edu/human_bio/activities/karyotyping/karyotyping.html
After all the lessons in the mini-unit have been completed, make note of adjustments you would make when using this unit again.

Throughout this unit, students are encouraged to perform hands-on activities that enable them to observe specific examples of genetic inheritance in everyday life.

In addition, they use coin tosses to simulate genetic crosses and recognize the probability of specific outcomes.

Students are asked to hypothesize, record and analyze data, and recognize the importance of repeating an investigation numerous times to consider the data valid.
As we connect science to our students’ lives, consider the following points:

- Some of our students will have experienced family disruption, been fostered or adopted, or may in other ways be disconnected from their birth families. Therefore, consider using terms like “birth parent” or “biological parent,” rather than “parent,” when explaining how children receive certain phenotypes. Speaking Positively: Using Respectful Adoption Language, a 2004 article by adoption and infertility educator Patricia Irwin Johnston, can be found at:

  [http://www.perspectivespress.com/pjpal.html](http://www.perspectivespress.com/pjpal.html)

For similar reasons, creating a family tree or similar genetics activity (as suggested in several texts) is not recommended. If such an activity is undertaken, this should be done with care and sensitivity. A web search using the terms, “adoption family tree” yields a number of alternative activities that recognize the complexity of human relationships, and reflect a meaning for “family” that extends beyond traditional family trees.

- When implementing the activity, “Probability of Gender,” accurate language will reflect that we are talking about determining the biological sex of a baby. This activity does not investigate the determination of gender, which is considered to be a more socially constructed component of identity.

- For their own future health and for that of their families, it is important that students understand how genetic illnesses can be inherited. In such discussions, the issue of specific groups at risk for certain genetic diseases will come up. It is accurate to refer to genetic information based on ancestral or geographic origins, rather than races or racial groups.

- This may be an appropriate unit in which to introduce the idea that, biologically speaking, there are no true distinctions based on “race.” A Google search using the key terms, <Does Race Exist?> and <Scientific American> will lead directly to a strong resource article, “Does Race Exist?” from the December 2003 cover story in Scientific American by Michael J. Bamshad and Steve E. Olson.

A digital copy of this article may be purchased at:

Suggested Choices from Real MCAS Questions

2004 Biology Grades 9/10  Question 6  Multiple Choice
2004 Biology Grades 9/10  Question 18  Open Response
2005 Biology Grades 9/10  Question 3  Multiple Choice
2005 Biology Grades 9/10  Question 13  Multiple Choice
2006 Biology Grades 9/10  Question 6  Multiple Choice
2006 Biology Grades 9/10  Question 21  Multiple Choice
2006 Biology Grades 9/10  Question 26  Open Response
2006 Biology Grades 9/10  Question 35  Multiple Choice
2006 Biology Grades 9/10  Question 36  Multiple Choice

Have students read the information provided in each MCAS problem and discuss how these problems are similar to the work in their previous lessons.

Have students choose one of the problems for the class to work on together at the board. Be sure to demonstrate how they should clearly write their solutions and their work.

Give students time to work on the rest of the problems, either independently or in a small group. For the 2004 Biology Grade 9/10 Open Response Question 18, ask students to write their solutions “so that someone else would be able to understand their thinking.”

(Note: examples of student answers to this question have been published by the Department of Education on their website, and have been reproduced in the Assessment chapter of this Instructional Guide for ease of reference.)

Using an overhead if possible, show the exemplars that can be found online, at least for 1-point, 2-point, and 4-point questions.

http://www.doe.mass.edu/mcas/search/
Mary McCarthy
mccarthm@arps.org

Biology
Mendelian Genetics

Introductory/Pre-Assessment

By the end of this mini-unit, students should:

**KNOW**

- DNA is the genetic material, contained in genes in the chromosomes of each cell. (Review from previous units)
- Meiosis produces haploid cells, sperm and egg (ovum). (Review from previous units)
- A child receives one complete set of 23 chromosomes from each biological parent, for a total of 46. The 23rd pair includes the sex chromosomes or the X and Y chromosomes.
- Definition of probability.

**UNDERSTAND**

- That coin tosses can model genetic probability.
- That the X and Y chromosomes are inherited from biological parents and determine the sex of a child, male or female.

and therefore be able to **DO**

- Predict the percent chance of producing a female or male child by performing simple probability problems. (Example) Students carry out coin tosses to predict the percent change of producing a female or male child.
**B 3.1**
Describe the function of DNA in genetic inheritance.
(Review from previous units.)

**B 3.4 (EMPHASIZED STANDARD)**
Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, codominant, sex-linked, polygenic, incomplete dominance, multiple alleles).

**Mathematical Skills**
Using ratios and proportions to solve problems.

Describe student **GROUPING**; students can work alone or with a partner for this activity.

How will the lesson be **DIFFERENTIATED**?

This lesson includes visual, auditory, and hands-on, approaches, as well as mathematical components.

Depending on the time available, teacher may decide to pre-wrap and mark the coins, rather than having students do this.

It may also be helpful to have questions written on the board as prompts, for example: “What determines whether a couple will have a son or a daughter?”

- Coins (2 per student or per group)
- Photocopied handouts of Exercise 48, “Probability of Gender”
- Pencils
- Masking tape
- Student notebooks (if students will be writing down responses)
- Calculators (optional, but helpful)
- *Biology: Cycles of Life* textbook, page 278
- Board and markers
- Access to the internet (optional)
GENETICS MINI-UNIT: SAMPLE LESSON EXEMPLAR (continued)

PRE-ASSESSMENT

- Oral survey, or matching or diagram game, drawing upon student’s prior knowledge of DNA and meiosis from preceding unit.

- Through discussion or journaling, have the students explain what they know about what determines whether a couple will have a son or a daughter.

ESSENTIAL QUESTION

What determines whether two biological parents will have a son or a daughter?

BACKGROUND

Students should have studied DNA, mitosis, and meiosis prior to this unit. They will draw upon their prior knowledge of these topics to begin their study of genetics, how characteristics are inherited.

MOTIVATOR, VISUAL CUE and REVIEW

“You have already learned about the molecule containing our genes; which molecule is that?” (DNA) “Today, we will begin to study how genes are passed on from the biological parent to the child. Let’s start by looking at where DNA is in our bodies.”

On the Web, go to:

http://www.thetech.org/exhibits/online/ugenetics/

- Scroll down to “Zooming Into DNA.”
- This site displays a series of photos and micrographs at increasing magnifications. You must click on each image in succession (hand → skin → cells → etc., all the way to DNA). There are great pictures of the X and Y chromosome included! At later steps, be sure to note to students how powerful the magnification is.

While students view the karyotype, it is a good time to continue the review:
- How many chromosomes does a human have? (46)
- Where did this individual pictured obtain 2 of each chromosome? (One from each biological parent.)
- What process reduces the chromosome number? (meiosis)
- Point out the X and Y chromosomes; advise students that these are the sex cells, to be discussed later.
- The shape of DNA can also be reviewed using the photos.

Students should take notes on key terms and symbols and/or highlight key terms in a handout or reading they have received. As new terminology is introduced, the teacher writes key vocabulary words on the board (or may already have displayed them on a word wall).
A child receives one complete set of 23 chromosomes from each biological parent, for a total of 46.

Sex cells (a.k.a., ova/eggs and sperm cells) contain 23 chromosomes each, and include only one copy of either an X or Y chromosome.

XX (two copies of an X chromosome) indicates a female; XY (one copy of an X and one copy of a Y chromosome) indicates a male.

Introduce the term “probability.”

Data Collection:
- Remind students that they probably know families with all girls, all boys, or a mix of both. What determines this? Students will do an exercise to test their ideas.

- Students should make a hypothesis about what they think the percent chance or likelihood is that a couple will produce a son or a daughter.

- Students cover 2 coins with masking tape, writing X on both sides of one to represent the chromosomes that may come from the mother. On the other coin, students should write X on one side and Y on the other to represent the chromosomes that may come from the father.

- Following Exercise 48, “Probability of Gender,” students throw coins repeatedly to simulate various ways the gametes could combine.

- Students record their data; then class data is collected.

Evaluation:
- As the students are working on the activity, move around the room asking individual students to explain how the coin toss activity demonstrates the genetic probability of a man and a woman having a son or a daughter.

- Have students discuss their results in pairs, then with the whole class. Why do they think they got the results they did? Were their hypotheses proven or disproven? Why did we perform several coin tosses, instead of just one or two? Why did we combine results before making a conclusion? (Mention that scientists repeat experiments many times before agreeing that a hypothesis has been proven.)

- Be sure to address the new information that students learned by asking them to review their initial responses from the pre-assessment. Discuss what they have learned.
Students can investigate increasingly complex questions:

- A couple has twin girls. What is the likelihood their next child will be a girl? Is it the same as the chance that a couple will have 2 girls in a row?

- What are the chances for a couple with 3 children that 2 of them will be girls? Are these problems solved the same way?

- Determine the types of sex chromosomes that either the mother or the father can contribute. (Women only have X chromosomes, but men have one X and one Y.)

- Further discuss who therefore determines the sex of a child—the biological mother or father? Make connections to historical events and practices, such as royalty holding the mother accountable if she does not produce a male heir to the throne.

**LESSON REFLECTION**

**Stage 1**

How do you PLAN TO EVALUATE whether students achieved the learning objectives? Consider, for example, how you will gauge a student’s understanding of the role of X and Y chromosomes in determining the sex of a baby?

**Stage 2**

Now that the lesson has been DONE, reflect on what data you have that informs you regarding students’ achievement of the learning objectives.

**Stage 3**

If you were to repeat this lesson, what would you ADJUST / MODIFY?

**Stage 4**

Based on THIS lesson and student performance, what do you want or need to modify for the NEXT lesson?
Just for fun—a cartoon imagining that regions of chromosomes control specific human characteristics.

http://members.fortunecity.com/anemaw/chromosomes.jpg
Jennifer Welborn
markwelborn@comcast.net

Biology, particularly standard **B 6.3**
Food Webs

By the end of this activity, students should:

**KNOW:**
(factual information)

Definitions for Key Terms:
- Primary consumers
- Secondary consumers
- Tertiary consumers
- Trophic levels
- Energy pyramid

The roles and relationships among producers, consumers, and decomposers in a food chain or food web

That energy flows through a food chain or food web within a habitat and/or ecosystem

That food webs or food chains are often represented by a diagram.

That biological communities include organisms in varying relationships to each other (predation, parasitism, competition, commensalism, and mutualism)

**UNDERSTAND:**
(big ideas, concepts,
Essential Questions)

The importance of the sun as the original source of energy for a food chain/web

The difference between a food chain and a food web

Why producers are the base of every food chain

How transferred energy decreases at each successive level of a food chain (energy pyramid)

That symbiotic relationships between organisms in a community generally relate to an organism obtaining food, or avoiding becoming food for another organism
Build a mobile or a poster representing a food web (including humans) that demonstrates the energy cycle. Know and Understand objectives should be included.

Make observations, raise questions, formulate hypotheses and predictions both verbally & in writing (Standard SIS1)

Predict what might happen if a single kind of organism were removed from a food web

Predict how a particular food web might be affected if an ecosystem were destroyed

Work collaboratively to reach the objectives (5Es)

(Homework) Predict what would happen if one of the organisms in the web were no longer to exist; write a response explaining your reasoning

**B 6.3**

Use a food web to identify and distinguish producers, consumers, and decomposers, and explain the transfer of energy through trophic levels. Describe how relationships among organisms (predation, parasitism, competition, commensalism, mutualism) add to the complexity of biological communities.

**LS 13, 14**

**SIS1**

- Make observations, raise questions, and formulate hypotheses.
- Observe the world from a scientific perspective.
- Pose questions and form hypotheses based on personal observations, scientific articles, experiments, and knowledge.
RESOURCES & MATERIALS

• chalk or white board
• paper
• pencils (regular and colored)
• scissors
• plastic hangers
• straws or popsicle sticks
• yarn
• hole-punches
• colored construction paper
• reference books and/or access to the internet
• example of a mobile or poster—without key term headers

To serve as examples, you will also need images (from magazines or the internet) representing humans, cows (beef), grass, chickens, corn or grain, bread (wheat), mushrooms, sharks, salmon, bacteria, small aquatic insects, aquatic plants, and small terrestrial insects

LESSON DETAILS

Before class, the teacher will write the learning objectives on the board (and/or a hand out) with the Essential Question/s highlighted

The teacher will review the day's learning objectives (either reading them aloud or having students read different parts) ~ 5 minutes

The teacher will hold up a pre-made example of a mobile or poster without any key term headers, and ask students to reflect on and write about what they notice in the poster or mobile ~ 7 minutes for Pre-Assessment

Students will then pair up with a neighbor to compare reflections; while students are comparing reflections, the teacher will ask students to highlight any key terms from the objectives that they believe were correctly used in their reflection ~ 3 minutes

Then student pairs will report their combined lists to the class, while the teacher writes responses on the board ~ 5 minutes for the whole group

Independently or in pairs, students will then have the opportunity to create their own mobiles or posters of a food web, being sure to include as many aspects of the class’s combined list as possible ~ 20 minutes

The teacher will make her way around the room checking in with students or pairs of students working on their projects. Wrap up will consist of students presenting their foodweb to the class ~7 minutes

To end the lesson, hand out and go over homework assignment ~2 minutes

(Predict what would happen if one of the organisms in the web were no longer to exist; write a response explaining your reasoning)
OUTLINE OF ACTIVITIES
Lessons, tasks, and activities to support students’ achievement of learning objectives

1 Sort the pictures into groups according to trophic level: producers, herbivores (primary consumers), carnivores (secondary and tertiary consumers), and decomposers; while students are sorting, they should be free to ask questions of one another and of the teacher.

2 Glue the images onto color-coded squares of construction paper. For example, glue producers (primary consumers) on yellow paper, herbivores on green paper, secondary consumers (carnivores) on red paper, and decomposers on blue paper.

3 Each pair of students or individual student will need a plastic hanger, yarn, straws or popsicle sticks, scissors and a hole-punch to construct a hanging mobile that shows the food web relationships among the organisms (See instructions below under “alternative activities,” if you are unable to build models at your site).

4 To complete the mobile, first punch holes in the top of each square, then link the squares together with yarn according to the corresponding organisms’ trophic levels. Tertiary consumers should be at the top of the mobile, nearest the hanger, while producers and decomposers should be at the bottom. If they have more than one organism at the same trophic level (i.e., cows and chickens), straws or popsicle sticks can be used to "branch" the web, attaching one square to each end of the straw or stick, and attaching the yarn to the middle section. The levels should be the same on the poster and the mobile.

Choices include creating a mobile or poster; if a student wanted to write an essay or a poem, this could also be an option.

Multiple student grouping options include individual, pairs, small and whole groups; multiple learning styles (e.g., kinesthetic, auditory, visual, etc.) are incorporated.

The lesson is centered around standards from high school biology and middle school physical science, with tasks scaffolded to allow all students to demonstrate their cognitive readiness levels through questions, answers, or products.

DIFFERENTIATION OF:

Product

Process

Content
If there are enough students, one alternative activity would be to have each student hold a picture of one of the organisms, and then run pieces of yarn in between the students to illustrate the food web, indicating which organism gets eaten by which other organism.

Another alternative activity would be to glue the color-coded squares with pictures mounted on them onto a large piece of paper. Using a pencil, draw lines connecting each organism with what it eats, and with what eats it. If students use a pencil, they can erase certain links to show what would happen if one of the organisms no longer existed.

If you are unable to build models at your site, or to have an alternative for students to work on, plan to provide each pair of students with materials so that they can create a poster with the pictures; a good site to find simple pictures of various animals is listed below:

- [http://www.zephyrus.co.uk/foodpuzzlechain.html](http://www.zephyrus.co.uk/foodpuzzlechain.html)

A final alternative activity would be to go to one or more of the following websites, where students can build their own food webs online:


Energy cycles through an ecosystem, as illustrated in the graphics below and to the right:
OUTLINE OF ACTIVITIES
Lesson tasks and activities to support students’ achievement of learning objectives

BACKGROUND FOR TEACHERS

"Fitting Algae Into the Food Web,” an internet resource at

http://www.bigelow.org/edhab/fitting_algae.html

provides an overview of food webs and food chains, leading to a discussion of oceanic consumers, producers, and decomposers. This site also includes further activities for the class.

After the Problem of the Day is completed, make note of adjustments you would make when using this unit again.

ADDITIONAL RESOURCES

REFLECTION
teaching in DYS schools
CHEMISTRY
In all DYS settings, the primary focus of science instruction is Biology, which shall be taught through a combination of mini-units, Problems of the Day, and other lessons and instructional strategies, as appropriate to each type of setting. Additionally, SCIENTIFIC INQUIRY SKILLS are essential to good teaching and should be integrated into all science topics and strands.

In instances where students have completed the Biology strand in their previous school, and/or when students were engaged in learning other strands in their previous school, students will require instruction in CHEMISTRY or Physics. A full scope and sequence, as well as curriculum exemplars in Biology, Chemistry, and Introductory Physics, is included in this Instructional Guide.
The graphic below is repeated throughout this section to suggest sequencing and an approach to teaching each Strand of the Science Curriculum Framework. Allocation of time for each topic should be flexible in response to holidays, periods of MCAS testing, and other factors.

**LEARNING OBJECTIVES**

For each strand and emphasized standard, an extended grid outlines what students should KNOW, UNDERSTAND, and be able to DO to demonstrate progress toward specific learning objectives. Primary resources are indicated, and because specialized vocabulary is vital to science learning, important new terminology is highlighted for emphasis.

**LESSON PLANNING**

The extended KNOW-UNDERSTAND-DO grids are carefully designed to help teachers in all DYS settings develop rigorously standards-based teaching activities. The order of topics in each strand (above) is suggested, but it is not required; the needs of the students and the type of setting will also affect how teachers proceed through each strand.

**EXEMPLARS**

A set of exemplary curricular materials is provided in this guide. Each exemplar (Mini-Unit, Lesson, and Problem of the Day) is fully elaborated, offering DYS teachers strong models to use in developing and sharing their own teaching materials. A blank template for developing lessons is provided in the Biology section, following the Genetics Mini-Unit and the demonstration lesson. (Look for additional materials to complement this guide on CD.)
### Key topics in Chemistry

<table>
<thead>
<tr>
<th>Properties of Matter</th>
<th>Related Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C 1.1</strong></td>
<td>Identify and explain physical properties (e.g., density, melting point, boiling point, conductivity, malleability) and chemical properties (e.g., the ability to form new substances). Distinguish between chemical and physical changes.</td>
</tr>
<tr>
<td><strong>Ps 2, 9, 10</strong></td>
<td></td>
</tr>
<tr>
<td><strong>C 1.2</strong></td>
<td>Explain the difference between pure substances (elements and compounds) and mixtures. Differentiate between heterogeneous and homogeneous mixtures.</td>
</tr>
<tr>
<td><strong>Ps 5, 6, 8</strong></td>
<td></td>
</tr>
</tbody>
</table>
## Learning Objectives

<table>
<thead>
<tr>
<th>STUDENTS SHOULD KNOW</th>
<th>UNDERSTAND (Essential Questions)</th>
<th>AND BE ABLE TO DO</th>
</tr>
</thead>
<tbody>
<tr>
<td>‣ That <strong>physical properties</strong> are characteristics that do not change the substance</td>
<td>‣ That physical changes do not change what the substance is</td>
<td>‣ Determine the identity of or physical property of an unknown object/substance when given samples of data (tables, charts, and/or graphs)</td>
</tr>
<tr>
<td>‣ That <strong>chemical properties</strong> are characteristics that show how a substance could change into something different</td>
<td>‣ That the particles in matter are constantly in motion, but they have different amounts of motion and energy in each of the three states of matter—solid, liquid, gas (refer to Standard C 1.3)</td>
<td>‣ Interpret the density of unknown objects/substances based on comparison within a density column (a density column is composed of layers of solutions with differing densities, with the densest solution at the bottom)</td>
</tr>
<tr>
<td>‣ Examples of physical and chemical properties</td>
<td>‣ Chemical changes do not create something new but instead change the original substance into a different substance or substances</td>
<td>‣ Describe characteristics of phase changes and the states of matter involved (evaporation, melting, etc.)</td>
</tr>
<tr>
<td>‣ That <strong>physical changes</strong> are changes in the substance related to temperature, shape, size, state of matter, etc.</td>
<td></td>
<td>‣ Create a 4-1 frame cartoon strip explaining the difference between chemical and physical changes</td>
</tr>
<tr>
<td>‣ That <strong>chemical changes</strong> are changes in a substance that result in the formation of a totally new substance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‣ That <strong>elements</strong> are composed of only one kind of particle—<strong>atom</strong></td>
<td>‣ That the formation of compounds occurs when the atoms of two or more elements combine by undergoing a chemical change</td>
<td>‣ Identify examples of pure substances (elements and compounds) and mixtures</td>
</tr>
<tr>
<td>‣ That <strong>compounds</strong> are composed of only one kind of particle—<strong>molecule</strong></td>
<td>‣ Elements and compounds cannot be physically separated</td>
<td>‣ Describe similarities and differences between the following using a Venn diagram:  • Elements vs. compounds  • Pure substances and mixtures</td>
</tr>
<tr>
<td>‣ That elements undergo chemical changes, combining to make different compounds</td>
<td>‣ Mixtures can be separated back into two or more different and often simpler substances</td>
<td>‣ Compare and contrast homogeneous and heterogeneous mixtures; identify and provide examples of each</td>
</tr>
<tr>
<td>‣ That <strong>mixtures</strong> are composed of different particles from different substances</td>
<td></td>
<td>‣ Create homogeneous and heterogeneous mixtures using household items</td>
</tr>
<tr>
<td>‣ The difference between <strong>heterogeneous mixtures</strong> and <strong>homogeneous mixtures</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Key topics in Chemistry

<table>
<thead>
<tr>
<th>ATOMIC STRUCTURE AND NUCLEAR CHEMISTRY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection: See Biology: Cycles of Life, Chapter 2, Basic Chemistry, subsection: <em>Atoms and Molecules</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RELATED STANDARDS</th>
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</thead>
<tbody>
<tr>
<td><strong>C 2.2</strong></td>
</tr>
<tr>
<td>Describe Rutherford’s “gold foil” experiment that led to the discovery of the nuclear atom. Identify the major components (protons, neutrons, and electrons) of the nuclear atom and explain how they interact.</td>
</tr>
<tr>
<td><strong>PS 6</strong></td>
</tr>
</tbody>
</table>
## Learning Objectives

<table>
<thead>
<tr>
<th>STUDENTS SHOULD KNOW</th>
<th>UNDERSTAND (Essential Questions)</th>
<th>AND BE ABLE TO DO</th>
</tr>
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</table>
| That atoms are made of three basic parts, or **subatomic particles: protons, neutrons, and electrons** | When a “neutral” atom is not bonded (connected) with another atom, it has the same number of protons and electrons:  
  When there are more or less electrons than protons, the charges are not balanced and the atom is called an **ion**  
  That most of the atom’s mass is located in the nucleus.  
  That neutrons play an important role in the atom. Changes in the number of neutrons results in the formation of **isotopes** | Construct a model of an atom and its subatomic particles: protons, neutrons, and electrons, paying attention to placement and differences in size  
  Argue which subatomic particle the student thinks might be the most important by comparing the properties of each (i.e., electric charge, mass (in atomic mass units (amu), and location)  
  Explain where most of the atom’s mass is located and why  
  Identify when an atom is “neutral” given the number of protons and electrons present in the atom |
| That protons have a positive electric charge, and electrons have a negative electric charge; neutrons have no electric charge but play an important role in the atom |                                                                                               |                                                                                                                                                  |
| That protons and neutrons are found in the **nucleus**, or the center, of an atom: All atoms of the same element have the same number of protons |                                                                                               |                                                                                                                                                  |
| That electrons, which are much smaller in size and mass, move around the nucleus in **energy levels** or **orbitals** |                                                                                               |                                                                                                                                                  |
### Key topics in Chemistry

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**C 2.5**

Identify the three main types of radioactive decay (alpha, beta, and gamma) and compare their properties (composition, mass, charge, and penetrating power).
## Learning Objectives

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<tbody>
<tr>
<td>› That isotopes with too many or too few neutrons are unstable and thus radioactive</td>
<td>› That radioactive decay begins with unstable elements and results in more stable products</td>
<td>› Compare and contrast the different types of radioactive decay and their properties, being sure to include:</td>
</tr>
<tr>
<td>› Release of radiation is radioactivity. This occurs when an unstable nucleus begins to break down, a process called <strong>radioactive decay</strong></td>
<td>› Radioactive decay is the loss of energy through radiation in the form of particles or electromagnetic waves</td>
<td>• Differences in what is emitted during the process,</td>
</tr>
<tr>
<td>› The three basic types of radioactive decay: <strong>alpha decay</strong>, beta decay, and gamma decay.</td>
<td>› Radioactive decay is used in many helpful ways (i.e., smoke detectors and medical treatments)</td>
<td>• The process involved,</td>
</tr>
<tr>
<td>› Both alpha and beta decay changes the original isotope into a different element through a process called <strong>transmutation</strong></td>
<td></td>
<td>• The changes that the original isotope undergoes, and</td>
</tr>
<tr>
<td>› How the <strong>half-life</strong> of an element is related to radioactive decay (refer to Standard C 2.6)</td>
<td></td>
<td>• Examples of each</td>
</tr>
</tbody>
</table>

› Describe natural forms of nuclear reactions such as radioactive decay in contrast to other types such as nuclear bombardment (**nuclear fission** and **nuclear fusion**) (refer to Standard C 2.7)
### Key topics in Chemistry

<table>
<thead>
<tr>
<th>PERIODICITY</th>
<th>RELATED STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C 3.1</strong></td>
<td>Explain the relationship of an element’s position on the periodic table to its atomic number. Identify families (groups) and periods on the periodic table.</td>
</tr>
</tbody>
</table>
## Learning Objectives

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<tbody>
<tr>
<td>That elements located near the top of the periodic table have smaller <strong>atomic numbers</strong> than those located at the bottom</td>
<td>That no two elements have the same number of protons, and thus, no two elements have the same atomic number</td>
<td>Construct a periodic table to show patterns of elements within the same rows and/or columns</td>
</tr>
<tr>
<td>That elements on the left side of each row on the periodic table have smaller atomic numbers than the rest of the elements in the same row</td>
<td>Elements with greater atomic numbers often have greater atomic masses</td>
<td>Based on an element’s position on the periodic table, determine if it is a metal or nonmetal (refer to Standard C 3.2)</td>
</tr>
<tr>
<td>That the horizontal rows on the periodic table are called <strong>periods</strong></td>
<td>Elements in the same family often have similar physical and chemical properties</td>
<td>Describe similarities and differences of one element in relation to other elements</td>
</tr>
<tr>
<td>That the vertical columns on the periodic table are called <strong>families</strong> or <strong>groups</strong></td>
<td></td>
<td>Create “family books” describing each member (element) found in any given family (or column) on the periodic table</td>
</tr>
<tr>
<td>That an element’s position in the periodic table determines which class of elements it is in: metals, nonmetals, or metalloids (refer to Standard C 3.2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### What Chemistry Should Students Know?

<table>
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<tr>
<th>Key topics in Chemistry</th>
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<tr>
<td><strong>PERIODICITY</strong></td>
<td></td>
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</tbody>
</table>

**C 3.3**

Relate the position of an element on the periodic table to its electron configuration and compare its reactivity to the reactivity of other elements in the table.

**PS 5**
## Learning Objectives

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</thead>
<tbody>
<tr>
<td>‣ That the atomic number (or number of protons) determines the total number of electrons. Each energy level can only hold a set number of electrons</td>
<td>‣ That an element’s position on the periodic table has a strong relationship to its electron configuration and its reactivity to other elements</td>
<td>‣ Based on the electron configuration of an element, determine its most likely position on the periodic table</td>
</tr>
<tr>
<td>‣ The electron configurations for the first twenty elements of the periodic table (refer to Standard C 2.4)</td>
<td>‣ That elements in the same family have the same number of valence electrons and thus similar reactivity</td>
<td>‣ Identify elements with high electronegativity</td>
</tr>
<tr>
<td>‣ That electrons, especially valence electrons, of an atom play a crucial role in an element’s reactivity (how it bonds or connects to atoms of other elements): • Based on the number of valence electrons, atoms can gain or lose electrons forming anions or cations, respectively</td>
<td>‣ That there are patterns in the periodic table related to the size of atoms and ions, ionization energy, and electronegativity of different elements (refer to Standard C 3.4)</td>
<td>‣ Explain the role of electrons in chemical reactions by describing the process by which two atoms bond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‣ Identify anions or cations when represented by symbol only and describe their reactivity—for example, $^{16}$O$^-$ or $^7$Li$^+$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‣ Investigate different types of common chemical reactions between elements, and be able to explain why these elements combine based on the electron configuration of their atoms</td>
</tr>
</tbody>
</table>
## Key topics in Chemistry

<table>
<thead>
<tr>
<th>related standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHEMICAL BONDING</strong></td>
</tr>
<tr>
<td>Connection: See Biology: Cycles of Life, Chapter 2, Basic Chemistry, subsections: <em>Chemical Formulas</em> and <em>Bonding Patterns</em></td>
</tr>
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</table>

### C 4.1

Explain how atoms combine to form compounds through both ionic and covalent bonding. Predict chemical formulas based on the number of valence electrons.

### P5, 6
<table>
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</thead>
<tbody>
<tr>
<td>▸ The difference between monatomic, diatomic, and polyatomic atoms/molecules</td>
<td>▸ That the goal of both ionic and covalent bonding is to completely fill the last energy level, or orbital, of each bonding atom</td>
<td>▸ Explain the role of electrons in a chemical reaction between atoms of different elements</td>
</tr>
<tr>
<td>▸ That atoms of different elements form bonds, thus combining to form compounds</td>
<td>▸ That an atom’s electrons determine its reactivity, and thus, electrons play a very important role in chemical bonding</td>
<td>▸ Describe what makes a covalent bond and what makes an ionic bond</td>
</tr>
<tr>
<td>▸ That ionic bonds form when atoms combine by losing or gaining valence electrons. This process occurs between positive and negative ions of different elements</td>
<td>▸ That when atoms gain or lose electrons in ionic bonding, the radius of the atoms will increase or decrease respectively</td>
<td>▸ Given a chemical formula, determine the shape and structure of a molecule (i.e., Lewis dot diagrams) (refer to Standard C 4.2)</td>
</tr>
<tr>
<td>▸ That covalent bonds form when atoms of different elements share valence electrons</td>
<td>▸ That chemical bonding between two or more elements forms compounds</td>
<td>▸ Predict the chemical formula for a compound (e.g., oxygen and beryllium form BeO)</td>
</tr>
</tbody>
</table>

CURRICULUM RESOURCES—CHEMISTRY

 HOW DO WE KNOW THAT THEY KNOW IT?
### Key topics in Chemistry

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<td>Connection: See Biology: Cycles of Life, Chapter 2, Basic Chemistry, subsection: <em>Chemical Formulas</em> and <em>Bonding Patterns</em></td>
</tr>
<tr>
<td><strong>C 4.6</strong></td>
</tr>
<tr>
<td>Name and write the chemical formulas for simple ionic and molecular compounds, including those that contain the polyatomic ions: ammonium, carbonate, hydroxide, nitrate, phosphate, and sulfate.</td>
</tr>
</tbody>
</table>

| **CHEMICAL REACTIONS AND STOICIOMETRY** |
| **C 5.1** |
| Balance chemical equations by applying the laws of conservation of mass and constant composition (definite proportions). |
| **PS 5, 6** |
# Learning Objectives

<table>
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<tbody>
<tr>
<td>Simple ionic and molecular compounds and their formulas such as, HCl (hydrochloric acid) or CaCO₃ (calcium chloride)</td>
<td>That the valence electrons of an atom will determine if it will form ionic or covalent bonds with other elements (tool: Lewis dot diagrams)</td>
<td>Determine the name of a compound when given its molecular formula</td>
</tr>
<tr>
<td>The chemical formulas for the following: Ammonium NH₄ Carbonate CO₃ Hydroxide OH⁻ Nitrate NO₃ Phosphate PO₄ Sulfate SO₄</td>
<td>That elements from one family on the periodic table will bond similarly to other elements from a different family. The ratio of atoms in the resulting molecule is always the same</td>
<td>Hypothesize the number of valence electrons of one element when given the molecular formula for a polyatomic compound</td>
</tr>
<tr>
<td>How chemical reactions demonstrate the law of conservation of matter and the law of conservation of mass</td>
<td>That matter is neither created nor destroyed (what goes into a reaction must come out in some form or another!).</td>
<td>Compare and contrast the common polyatomic ions (cations vs. anions, types of compounds they form, etc.)</td>
</tr>
<tr>
<td>That coefficients and subscripts are used to represent the total number of atoms of each element present in a chemical reaction</td>
<td>What it means for a chemical equation to be “balanced”</td>
<td>Investigate different examples of compounds that include the common polyatomic ions such as ammonium or nitrate</td>
</tr>
<tr>
<td>For balancing chemical equations, the student will be able to:</td>
<td>That coefficients represent the number of moles of each reactant and/or product in a chemical equation</td>
<td>For balancing chemical equations, the student will be able to:</td>
</tr>
<tr>
<td>Identify the reactants and products in sample chemical equations</td>
<td></td>
<td>Identify the reactants and products in sample chemical equations</td>
</tr>
<tr>
<td>Understand the meaning of the symbols used in an equation (→, +, (s), (l), (g), (aq), coefficients, subscripts)</td>
<td>Recognize when an equation is balanced, and solve unbalanced equations.</td>
<td>Understand the meaning of the symbols used in an equation (→, +, (s), (l), (g), (aq), coefficients, subscripts)</td>
</tr>
<tr>
<td>Write a balanced chemical equation based on a written description of the reaction</td>
<td></td>
<td>Write a balanced chemical equation based on a written description of the reaction</td>
</tr>
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</table>
### Key topics in Chemistry

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<tbody>
<tr>
<td><strong>C 5.2</strong></td>
<td></td>
</tr>
<tr>
<td>Classify chemical reactions as synthesis (combination), decomposition, single displacement (replacement), double displacement, and combustion.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STATES OF MATTER, KINETIC MOLECULAR THEORY, AND THERMOCHEMISTRY</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C 6.1</strong></td>
<td></td>
</tr>
<tr>
<td>Using the kinetic molecular theory, explain the behavior of gases and the relationship between pressure and volume (Boyle’s law), volume and temperature (Charles’s law), pressure and temperature (Gay-Lussac’s law), and the number of particles in a gas sample (Avogadro’s hypothesis). Use the combined gas law to determine changes in pressure, volume, and temperature.</td>
<td></td>
</tr>
</tbody>
</table>
# HOW DO WE KNOW THAT THEY KNOW IT?

## Learning Objectives

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</table>
| In general, what happens in a synthesis (or combination), decomposition, single displacement (or single replacement), and double displacement reaction:  
  - For example, in a decomposition reaction, one large reactant will break down into two or more smaller products | That chemical reactions are classified based on the type of reactants and products involved | Recognize examples of each type of reaction:  
  - When elements are represented by symbols or letters:  
    - \((AB \rightarrow A + B)\), and  
  - When elements are represented by their chemical abbreviations:  
    - \((2H_2O \rightarrow 2H_2 + O_2)\) |
<p>| The kinetic molecular theory (a.k.a., the kinetic model) of gases | That the gas laws apply to all gases, regardless of identity | Develop a story from the perspective of the gas molecules describing what happens to them in a light bulb when turned on or off using the kinetic molecular theory. |
| The gas laws that describe the behavior of gases: Boyle's law, Charles's Law, and Gay-Lussac's Law | That changing one factor (pressure, volume, temperature, or moles) affects the others | Describe the relationship between any of the four factors when illustrated in a graph |
| Avogadro's Hypothesis and how it relates to gases | That the relationship between pressure, volume, temperature, and/or moles is represented by a mathematical formula for each gas law | Explain the relationship between the pressure, volume, temperature, and moles of gases in a demonstration when one factor changes; for example, if two containers of equal size are filled with equal amounts of different gases that have the same (V), (T), and (P), then they must also have the same number of molecules (mole) |
| The combined gas law | How pressure ((P)), volume ((V)), temperature ((T)), moles ((n)) relate to each other and are measured based on each gas law | Use the combined gas law to determine changes in pressure, volume, and temperature |</p>
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<td><strong>C 6.3</strong></td>
</tr>
<tr>
<td>Using the kinetic molecular theory, describe and contrast the properties of gases, liquids, and solids. Explain, at the molecular level, the behavior of matter as it undergoes phase transitions.</td>
<td><strong>PS 15</strong></td>
</tr>
<tr>
<td><strong>SOLUTIONS, RATES OF REACTION, AND EQUILIBRIUM</strong></td>
<td><strong>C 7.3</strong></td>
</tr>
<tr>
<td>Identify the factors that affect the rate of a chemical reaction (temperature, mixing, concentration, particle size, surface area, catalyst)</td>
<td></td>
</tr>
</tbody>
</table>
### Learning Objectives

**STUDENTS SHOULD KNOW**

- That scientists have described **5 phases of matter** (solids, liquids, gases, plasma, and Bose-Einstein condensate)
- The three most common states of matter on earth, and the properties of each, based on the position and behavior of their particles (refer to Standard C 1.3)
  - **Solids** have a definite shape and volume
  - **Liquids** have a definite volume but not a definite shape, and
  - **Gases** have no definite shape or volume
- The relationship between temperature and the average kinetic energy of particles in matter
- That the tool to measure changes in average kinetic energy (particle speed) is the thermometer

**UNDERSTAND (Essential Questions)**

- All matter is made up of particles (atoms, and/or molecules) held together by **attracting forces**
  - That according to kinetic molecular theory, the particles that make up matter are always in motion
  - That during phase changes, the temperature and the average kinetic energy of particles in matter increases as the particles begin to move further apart (solid → liquid → gas)
  - Temperature is a measure of the **average speed of particles**.

**AND BE ABLE TO DO**

- Create a graph representing the relationship between temperature and average kinetic energy
- Draw the molecules of water showing their position relative to each other during phase changes from ice (solid) to water (liquid) to vapor (gas).
- Explain the behavior of the molecules of water during each phase change in relation to temperature, average kinetic energy, and position
- Design a concept map showing different everyday examples of the kinetic molecular theory in action

**STUDENTS SHOULD KNOW**

- That solutes dissolve into solvents (refer to C 7.1)
- How changes in any of the following factors can increase or decrease the rate of dissolving:
  - temperature (average kinetic energy)
  - concentration of solute or solvent
  - surface area of solute
  - pressure
  - rate of mixing
- What happens at the molecular level for each factor

**UNDERSTAND (Essential Questions)**

- That the process of dissolving occurs on the molecular level resulting in different degrees of solubility (also refer to Standard C 7.1)
  - That water is not the only type of solvent

**AND BE ABLE TO DO**

- Describe what happens when salt (solute) dissolves into water (solvent) (refer to Standard C 7.1)
- Explain how changes in temperature, concentration, surface area, pressure, and/or mixing can increase or decrease the rate of dissolving at the molecular level.
- Create a picture book using everyday examples, such as dissolving sugar into iced tea, to illustrate this standard and explain how various factors affect the rate of dissolving at the molecular level.
### Key topics in Chemistry

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<tbody>
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<td><strong>SOLUTIONS, RATES OF REACTION, AND EQUILIBRIUM</strong></td>
<td><strong>C 7.5</strong></td>
</tr>
<tr>
<td>Connection: See Biology: Cycles of Life, Chapter 6, ATP and Energy Cycles, subsection: <em>Enzymes and Energy Flow</em></td>
<td>Identify the factors that affect the rate of a chemical reaction (temperature, mixing, concentration, particle size, surface area, catalyst)</td>
</tr>
<tr>
<td><strong>ACIDS AND BASES AND OXIDATION-REDUCTION REACTIONS</strong></td>
<td><strong>C 8.1</strong></td>
</tr>
<tr>
<td></td>
<td>Define the Arrhenius theory of acids and bases in terms of the presence of hydronium and hydroxide ions in water and the Bronsted-Lowry theory of acids and bases in terms of proton donors and acceptors.</td>
</tr>
</tbody>
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| ▶ How changes in any of the following can increase or decrease the rate of a chemical reaction:  
  • Temperature (average kinetic energy)  
  • Rate of mixing,  
  • **Concentration**,  
  • Particle size,  
  • Surface area, and  
  • Presence of a **catalyst**  | ▶ That these factors affect chemical reactions at the molecular level  
▶ That reactions can be bidirectional when certain factors are changed and **shifts in equilibrium** occur (refer to Standard C 7.6)  | ▶ Identify examples that demonstrate an increase or decrease in the rate of a chemical reaction.  
▶ Create an informational brochure explaining why silver jewelry tarnishes faster in warmer temperatures and how you could slow down this chemical reaction or prevent it from occurring altogether.  
▶ Identify factors that can cause a shift in the direction (equilibrium) of a chemical reaction when provided sample chemical equations (refer to Standard C 7.6) |
| ▶ How changes in these factors can produce a shift in direction of a chemical reaction (refer to Standard C 7.6)  | ▶ That acids and bases are defined at the molecular level  
▶ An acid and a base can react with each other resulting in a neutralization reaction  | ▶ Compare and contrast why a compound is an acid or a base according to the Arrhenius theory versus the Bronsted-Lowry theory  
▶ Explain why compounds are considered acids or bases based on these two theories, when given sample chemical equations  
▶ Identify acids and bases in sample chemical equations based on both theories |
| ▶ That according to **Arrhenius’s theory**, acids produce **hydrogen ions** (H\(^{1+}\) or H\(^+\)) when dissolved in water, and bases produce hydroxide ions (OH\(^{-}\)) when dissolved in water  
▶ Hydronium ions (H\(_3\)O\(^{1+}\)) result when water (H\(_2\)O) accepts an H\(^{1+}\) ion  |  |  |
| ▶ That according to the **Bronsted-Lowry theory**, an acid is a compound that is a **proton donor** and a base is a compound that is a **proton acceptor**:  
▶ The hydrogen ion (H\(^{1+}\) or H\(^+\)) is a proton  |  |  |
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<td>Connection: See Biology: Cycles of Life, Chapter 2, Basic Chemistry, subsection: <em>Acids, Bases and pH</em></td>
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<td><strong>C 8.2</strong></td>
</tr>
<tr>
<td>Relate hydrogen ion concentrations to the pH scale and to acidic, basic, and neutral solutions. Compare and contrast the strengths of various common acids and bases (e.g., vinegar, baking soda, soap, citrus juice).</td>
</tr>
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<tr>
<td>▶️ That the <strong>pH scale</strong> describes the $H^{+}$ ion concentration of a solution</td>
<td>▶️ (refer to Standard C 7.6) That according to <strong>Le Chatelier’s principle</strong>:</td>
<td>▶️ Research common household acids and bases:</td>
</tr>
<tr>
<td>▶️ That pH values range from 0 (acidic) to 14 (basic):</td>
<td>▶️ Solutions with low pH values have higher concentrations of $H^{+}$ ions and thus lower $OH^{-}$ concentrations</td>
<td>▶️ Determine the pH value of each</td>
</tr>
<tr>
<td>▶️ Solutions with a pH of 7 are neutral;</td>
<td>▶️ Solutions with high pH values have lower concentrations of $H^{+}$ ions and thus higher $OH^{-}$ concentrations</td>
<td>▶️ Determine if each is a strong or weak acid or base</td>
</tr>
<tr>
<td>▶️ Solutions with a pH less than 7 are acidic; and</td>
<td>▶️ That pH values indicate the strength or weakness of an acid or base</td>
<td>▶️ Create a pH scale showing all of the researched acids and bases on a continuum</td>
</tr>
<tr>
<td>▶️ Solutions with a pH greater than 7 are basic.</td>
<td></td>
<td>▶️ Include pictures and brief descriptions for each</td>
</tr>
<tr>
<td>▶️ Examples of common acids and bases</td>
<td></td>
<td>▶️ Determine if each has a high or low concentration of hydrogen ions when provided examples of common acids and bases</td>
</tr>
</tbody>
</table>
**Problem of the Day**

1 class period

**Designer’s Name**
Jennifer Welborn

**Designer’s Email**
markwelborn@comcast.net

**Strand**
Chemistry

**Topic**
Kinetic molecular theory

**Learning Objectives**
By the end of this activity, students should:

**Know:**
(factual information)

- That scientists have described 5 **phases of matter** (solids, liquids, gases, plasma, Bose-Einstein condensate)

- The three most common states of matter on earth (solids, liquids, and gases), and their properties based on the position and behavior of their particles (refer to Standard C 1.3)
  - Solids have a definite shape and volume
  - Liquids have definite volume but no definite shape
  - Gases have neither definite shape nor definite volume

- The relationship between temperature and the average kinetic energy of particles in matter

- That the tool to measure changes in average kinetic energy (particle speed) is the thermometer

**Understand:**
(big ideas, concepts, essential questions)

- That all matter is made up of particles (atoms and/or molecules) held together by attracting forces

- That according to the kinetic molecular theory, the particles that make up matter are always in motion

- That during phase changes, the temperature and the average kinetic energy of particles in matter increases as the particles begin to move farther apart (solid → liquid → gas)

- Temperature is a measure of the average speed of particles

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**Exploring Liquids, Solids, & Gases**

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OUTLINE OF ACTIVITIES
Lesson tasks and activities to support students’ achievement of learning objectives

- Reflect on and write about everyday occurrences of phase changes
- Demonstrate how and why matter can change phase by adding energy to it (Kinesthetic activity)
- Create a cartoon, poster, or song that demonstrates a prediction about phase changes
- Make observations, raise questions, formulate hypotheses and predictions - both verbally & in writing
- Work collaboratively to reach the objectives (5Es)

...and therefore be able to DO

These Learning Objectives are tied to the following LEARNING STANDARDS

C 6.3
Using the kinetic molecular theory, describe and contrast the properties of gases, liquids, and solids. Explain, at the molecular level, the behavior of matter as it undergoes phase transitions.

PS 15

SIS1
- Make observations, raise questions, and formulate hypotheses.
- Observe the world from a scientific perspective.
- Pose questions and form hypotheses based on personal observations, scientific articles, experiments, and knowledge.

RESOURCES & MATERIALS

- Chalkboard or whiteboard
- pencils (regular and colored)
- small pieces of newspaper
- magnifying lens
- string (if needed)
- paper
- m&m candies or “energy tokens” with temperature written on it
- A terrific free trial for illustrating kinetic molecular theory that is available from: http://www.atomicmicroscope.com

Teacher will review the day’s learning objectives, either reading them out loud or having students read different parts ~ 5 minutes

As a pre-assessment, the teacher will then ask students to reflect on and write about one or more of the following questions: ~ 10 minutes

- Why does the candy coating on an m&m melt in your mouth, not in your hand?
- Why does a basketball look like it has lost air when it’s been left outside on a cold day?
- How does water form on the outside of a cold glass of water in the summertime?
LESSON DETAILS
(continued)

Have students look at the print on a newspaper with their eyes, then observe using a strong magnifying lens (in pairs). Then have students record their observations and present findings to the whole class. Students will (one hopes) point out that even though the letters appear solid, they are made up of very small dots with spaces in between them (the teacher can facilitate movement in this direction if needed) ~ 7 minutes

Ask students to hypothesize how this relates to all matter: solids, liquids, gases. Students should form a conclusion that, like the newprint, even though it often appears to be solid or uniform, solid, liquid, and gaseous matter is made of very small particles ~ 5 minutes

Tell students they are going to pretend to be particles: first they will be particles in a solid, then particles in a liquid, and then in a gas.

Have students stand in a circle with their arms locked with one another (if students are not allowed to lock arms in your program, have them hold pieces of string so the string is taut). Instruct students to move in place just a little (swaying back and forth about 6 inches or so) as they are standing together. Point out that, as a solid, they have a definite volume and shape.

Give one m&m or energy token with a written temperature to each student. Tell the students you are giving them energy. Instruct students to move a little more (12 inches or so) and to move farther apart but still keep their arms locked together (or keep the string fairly taut). Point out that when matter gains energy, the particles speed up and the distance between them increases.

Give two m&m candies or energy tokens to each student. Have the students unlock their arms (or let go of the string) and slowly move around one another. Ask students what phase of matter they are representing now. Point out that as a group, they have a definite volume, but no definite shape.

Give students another candy or energy token and instruct them to move a little faster and a little further apart and eventually to make their way back to their seats. This represents a liquid which that has been heated and expands. This is how a thermometer works ~ 10 minutes
Finally, have students (now sitting down and apart from one another) predict what would happen if they were given more energy. Students can either create a cartoon, poster, or song that demonstrates their prediction of the phase change/s.

For example, give the students the following instructions: “You are a cartoonist. Your task is to create a cartoon scenario illustrating the effect of temperature on the movement of molecules in a solid, liquid, or a gas. You will be using your cartoon to teach your classmates about the movement of molecules in the different states of matter and how an increase or decrease in temperature affects them. Be sure to address all aspects of the lesson objectives.” The teacher will move around the room checking in with students, or pairs of students, working on their projects.

~10 minutes

Collect work to create a display at a later time; then hand out and go over homework assignment: “Create a list of the different solids, liquids, and gases encountered that day, and how temperature affects an example from each category.”

Choices include cartoons, posters, or songs.

Multiple student grouping options (individual, pairs, small and whole group) and multiple learning styles are incorporated (e.g., kinesthetic, auditory, visual, etc.).

Lesson is centered around standards from high school chemistry and middle school physical science, with tasks scaffolded to allow all students to demonstrate their cognitive readiness levels via questions, answers, and products.

This would be a good opportunity to help students learn how to do a guided Web search at home or in school, as students could use the internet to find out other experiments that illustrate the effect of temperature. Two good websites are listed below, and there are many more! Students might also research the other two lesser-known states of matter: plasma & Bose-Einstein condensate.

http://chem4kids.com/

http://www.exploratorium.edu/hockey/index.html
PHYSICS
### Teaching in DYS Schools

#### Sequence of Topics in Physics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity, Speed, and Acceleration</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Newton’s Three Laws of Motion</td>
<td>3 weeks</td>
</tr>
<tr>
<td>Free-Body Force Diagrams</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Heat Energy Transfer</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Temperature and Average Kinetic Energy</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Relationships &amp; Temperature Changes</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Voltage</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Electromagnetic Spectrum</td>
<td>3 weeks</td>
</tr>
</tbody>
</table>

#### Addressing All Strands

The primary focus of DYS science instruction is Biology, which shall be taught through a combination of mini-units, Problems of the Day, and other lessons and instructional strategies, as appropriate to each type of setting. Additionally, SCIENTIFIC INQUIRY SKILLS are essential to good teaching and should be integrated into all science topics and strands.

In instances where students have completed the Biology strand in their previous school, and/or when students were engaged in learning other strands in their previous school, students will require instruction in Chemistry or Physics. A full scope and sequence, as well as curriculum exemplars in Biology, Chemistry, and Introductory Physics, is included in this Instructional Guide.
### LEARNING OBJECTIVES

For each strand and emphasized standard, an extended grid outlines what students should KNOW, UNDERSTAND, and be able to DO to demonstrate progress toward specific learning objectives. Primary resources are indicated, and because specialized vocabulary is vital to science learning, important new terminology is highlighted for emphasis.

### LESSON PLANNING

The extended KNOW-UNDERSTAND-DO grids are carefully designed to help teachers in all DYS settings develop rigorously standards-based teaching activities. The order of topics in each strand (above) is suggested, but it is not required; the needs of the students and the type of setting will also affect how teachers proceed through each strand.

### EXEMPLARS

A set of exemplary curricular materials is provided in this guide. Each exemplar (Mini-Unit, Lesson, and Problem of the Day) is fully elaborated, offering DYS teachers strong models to use in developing and sharing their own teaching materials. A blank template for developing lessons is provided in the Biology section, following the Genetics Mini-Unit and the demonstration lesson. (Look for additional materials to complement this guide on CD.)
<table>
<thead>
<tr>
<th>Key topics in Introductory Physics</th>
<th>RELATED STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MOTION AND FORCES</strong></td>
<td><strong>P 1.2</strong></td>
</tr>
<tr>
<td></td>
<td>Distinguish between displacement, distance, velocity, speed, and acceleration. Solve problems involving displacement, distance, velocity, speed, and constant acceleration.</td>
</tr>
<tr>
<td></td>
<td><strong>PS 11, 12</strong></td>
</tr>
</tbody>
</table>
| STUDENTS SHOULD KNOW | UNDERSTAND  
(Effective Questions) | AND BE ABLE TO DO |
|----------------------|-----------------------|-------------------|
| ‣ Know what **displacement**, **distance**, **velocity**, **speed**, and **acceleration** mean
  • For example, know that displacement specifies the position of a point or a particle in reference to an origin or a previous position | ‣ How these quantities are useful in our everyday lives
  ‣ How knowing physics can make one a better athlete
  ‣ That the difference and relationship between each quantity is the foundation of Newtonian (Classical Mechanics) Physics
  ‣ How classical physics is helpful in explaining large-scale phenomena (More advanced) | ‣ Compare and contrast vector and scalar quantities (refer to Standard P 1.1) of a number of
  • runners (human or animal), and/or
  • vehicles moving at different speeds
  NOTE: Comparing and contrasting these quantities can use a variety of different means:
  • Pictures
  • Graphs
  • Verbal Descriptions
  • Physically timed scenarios
  • Venn Diagrams |
| Solve problems involving displacement, distance, velocity, speed, and constant acceleration | Create and interpret graphs of 1-dimensional motion, such as position vs. time, distance vs. time, etc. (refer to Standard P 1.3) |
| Create word problems (either individually, in small groups, or in pairs) that fellow classmates solve | Interpret and apply solutions to:
  • actual physical problems, and/or
  • representations of physical problems (e.g., visual diagrams, pictures, graphs, and/or verbal word problems) |
### Key topics in Introductory Physics

<table>
<thead>
<tr>
<th>MOTION AND FORCES</th>
<th>RELATED STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P 1.4</strong></td>
<td>Interpret and apply Newton's three laws of motion</td>
</tr>
<tr>
<td><strong>PS 11, 12</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MOTION AND FORCES</th>
<th>RELATED STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P 1.5</strong></td>
<td>Use a free-body force diagram to show forces acting on a system consisting of a pair of interacting objects. For a diagram with only co-linear forces, determine the net force acting on a system and between the objects</td>
</tr>
<tr>
<td><strong>PS 11, 12</strong></td>
<td></td>
</tr>
</tbody>
</table>
## Learning Objectives

<table>
<thead>
<tr>
<th><strong>STUDENTS SHOULD KNOW</strong></th>
<th><strong>UNDERSTAND</strong> (Essential Questions)</th>
<th><strong>AND BE ABLE TO DO</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- The law of inertia</td>
<td>- That the three physical laws provide relationships between the forces acting on a body and the motion of the body</td>
<td>- Choose a sport to illustrate how the body uses Newton's laws of motion (e.g., draw a picture and label, find a picture in a book or magazine and summarize, compare and contrast different sports, etc.)</td>
</tr>
<tr>
<td>- The law of acceleration</td>
<td>- Why Newton's three laws of motion are important in our everyday experiences</td>
<td>- Create hypothetical problems to demonstrate and challenge the applicability of Newton's three laws of motion</td>
</tr>
<tr>
<td>- The law of reciprocal actions</td>
<td>- How Newton's original laws differ from our modern-day understanding and interpretations <em>(More advanced)</em></td>
<td>- Compare and contrast Newton's laws as originally stated with the modern day interpretation <em>(More advanced)</em></td>
</tr>
<tr>
<td>- That Newton's laws of motion describe the acceleration of massive objects</td>
<td>- Newton's first two laws of motion are mainly ideas taken from Galileo's work, with the third law being an important extension <em>(historical component)</em></td>
<td>-</td>
</tr>
</tbody>
</table>
### Key topics in Introductory Physics

<table>
<thead>
<tr>
<th>MOTION AND FORCES</th>
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</thead>
<tbody>
<tr>
<td><strong>RELATED STANDARDS</strong></td>
</tr>
</tbody>
</table>

**P 1.7**

Describe Newton's law of universal gravitation in terms of the attraction between two objects, their masses, and the distance between them

**ES 8**  
**PS 1, 11, 12**
# Learning Objectives

<table>
<thead>
<tr>
<th>STUDENTS SHOULD KNOW</th>
<th>UNDERSTAND (Essential Questions)</th>
<th>AND BE ABLE TO DO</th>
</tr>
</thead>
<tbody>
<tr>
<td>- That ALL objects exert gravitational influences on (attract) one another</td>
<td>- Why most gravitational forces are too minimal to be noticed</td>
<td>- In pairs or groups, compare small objects with different masses and shapes by recording the falling times of the objects from slowest to fastest</td>
</tr>
<tr>
<td>• The greater the masses are, the greater the force is</td>
<td>- How Newton's three laws of motion, combined with his law of universal gravitation, provide a way to describe not only our observations of planetary motion, but can help us make predictions about unobserved objects.</td>
<td></td>
</tr>
<tr>
<td>• The greater the distance is, the less the force is</td>
<td>- How we can use the law of universal gravitation for our benefit</td>
<td></td>
</tr>
<tr>
<td>- That pulling force (attraction) is directly proportional to the product of the objects’ masses, and inversely proportional to the distance between the objects’ centers</td>
<td></td>
<td>- Write and illustrate a story explaining what life would be like on a planet with a different gravitational force than on earth</td>
</tr>
<tr>
<td>- That Newton's laws of motion combined with his law of universal gravitation explain Kepler's laws of planetary motion.</td>
<td></td>
<td>- Devise “paper scales” to demonstrate how to calculate how much one would weigh on another planet</td>
</tr>
<tr>
<td>- That all falling objects experience constant acceleration when air resistance is not considered, no matter how much they weigh</td>
<td></td>
<td>- Create a scaled version of the solar system in the classroom that accurately represents the masses and gravitational forces between objects <em>(in treatment programs)</em></td>
</tr>
<tr>
<td>Key topics in Introductory Physics</td>
<td>RELATED STANDARDS</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-------------------</td>
<td></td>
</tr>
<tr>
<td>CONSERVATION OF ENERGY AND MOMENTUM</td>
<td>P 2.1</td>
<td></td>
</tr>
</tbody>
</table>

**P 2.1**

Interpret and provide examples that illustrate the law of conservation of energy.

**PS 13**
### Learning Objectives

<table>
<thead>
<tr>
<th>STUDENTS SHOULD KNOW</th>
<th>UNDERSTAND (Essential Questions)</th>
<th>AND BE ABLE TO DO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy cannot be created (made from nothing), or destroyed (disappear to nowhere), and that energy can be changed from one form to another (e.g., from electrical energy to heat energy)</td>
<td>Why we can possibly run out of fuels that provide useful kinds of energy, but we cannot run out of energy</td>
<td>Create a chart or concept map illustrating the six forms of energy, how each is useful in our everyday lives, and how each can be changed from one form to another</td>
</tr>
<tr>
<td>Energy is needed for life</td>
<td>How the law of conservation of energy is used both to explain daily phenomena and to make predictions</td>
<td>Explain why a roller coaster is a good example of the conservation of energy and momentum (refer to Standard P 2.2)</td>
</tr>
<tr>
<td>There is renewable and non-renewable energy</td>
<td>Why energy cannot be created or destroyed in a system</td>
<td>Build a simple model (i.e., a simplified or miniature roller coaster) that demonstrates the conservation of energy</td>
</tr>
<tr>
<td></td>
<td>How energy changes from one form to another in a system</td>
<td>Demonstrate ways to “save” energy (conserve resources) by developing and implementing a class- or program-wide project. Compare results with known data and re-evaluate to plan further improvements (in treatment programs)</td>
</tr>
</tbody>
</table>
### INTRODUCTORY PHYSICS

#### WHAT SHOULD STUDENTS KNOW?

<table>
<thead>
<tr>
<th>Key topics in Introductory Physics</th>
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</thead>
<tbody>
<tr>
<td>CONSERVATION OF ENERGY AND MOMENTUM</td>
<td></td>
</tr>
</tbody>
</table>

**P 2.3**

Describe both qualitatively and quantitatively how work can be expressed as a change in mechanical energy.

**PS 13**
# Learning Objectives

<table>
<thead>
<tr>
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<th>UNDERSTAND (Essential Questions)</th>
<th>AND BE ABLE TO DO</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ <strong>Mechanical work</strong> is the amount of energy transferred by a force (work = force x distance)</td>
<td>▶ Why mechanical work is generally a macroscopically measurable force</td>
<td>▶ Identify instances of mechanical work by watching volunteers (or a movie or the teacher) take turns lifting an object, walking and stopping with the object, and placing the object down in front of the class</td>
</tr>
<tr>
<td>▶ That the movement of an object must be in the direction of the force applied, if work is to be done</td>
<td>▶ How humans can use—and machines can be used to do—mechanical work, with numerous advantages</td>
<td>▶ Think of work tasks they have done that day, list in order of the amount of work done, and explain their reasoning for the order they chose</td>
</tr>
<tr>
<td>▶ That mechanical energy is part of an object’s total energy</td>
<td>▶ Why heat conduction is not considered mechanical work</td>
<td>▶ Calculate how much work is done to an object or system</td>
</tr>
<tr>
<td>▶ Mechanical energy of an object/system includes its <strong>kinetic</strong> and <strong>potential energy</strong>, since they are easily subject to change by mechanical work</td>
<td>▶ Why energy can be used without work being done, but work cannot be done without energy</td>
<td>▶ Create a simple machine to demonstrate mechanical work</td>
</tr>
<tr>
<td>▶ <strong>Thermal</strong> and <strong>rest energy</strong> are not forms of energy typically included in an object’s total mechanical energy</td>
<td>▶ Why kinetic and potential energy are easily changed by mechanical work, but thermal and rest energy are not <em>(More advanced)</em></td>
<td>▶ Find examples of machines in the classroom or program and keep a record/chart of the type of machine and why it makes work easier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Draw parts of the body that are useful machines (e.g., levers with fulcrums), and demonstrate the use of these parts in instances of doing work</td>
</tr>
<tr>
<td><strong>HEAT AND HEAT TRANSFER-1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>RELATED STANDARDS</strong></th>
</tr>
</thead>
</table>

**P 3.2**

Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached.

**PS 14, 15, 16**
### Learning Objectives

<table>
<thead>
<tr>
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<th>UNDERSTAND (Essential Questions)</th>
<th>AND BE ABLE TO DO</th>
</tr>
</thead>
<tbody>
<tr>
<td>- It is a common misconception to confuse <strong>heat</strong> with internal energy; a hot object contains internal energy, not heat</td>
<td>- The relationship and difference between heat energy and temperature</td>
<td>- Identify objects in the room with the same temperature but different heat energy</td>
</tr>
<tr>
<td>- Heat is a form of energy transfer</td>
<td>- How temperature differences between objects creates a situation for energy transfer</td>
<td>- Explain the difference between temperature and heat</td>
</tr>
<tr>
<td>- Heat is the transfer of energy caused by a temperature difference between or within objects</td>
<td>- How temperature differences between objects relate to heating homes, our bodies, and even the interaction between the two</td>
<td>- Compare and contrast how matter is heated by radiation, conduction, and convection (refer to Standard P 3.1)</td>
</tr>
<tr>
<td>- Heat energy will move from a higher temperature to a lower temperature until equilibrium is reached</td>
<td>- Why the ocean's temperature can be less than a cup of hot water, but have more internal energy</td>
<td>- Design and build a “model home” out of different materials to experiment with the rate of energy transfer (for example, using a soda bottle container and a thermometer)</td>
</tr>
<tr>
<td>- Heat is mainly transferred between objects by <strong>radiation</strong>, <strong>conduction</strong>, and <strong>convection</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Key topics in Introductory Physics

<table>
<thead>
<tr>
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</table>

**P 3.3**

Describe the relationship between average molecular kinetic energy and temperature. Recognize that energy is absorbed when a substance changes from a solid to a liquid to a gas, and that energy is released when a substance changes from a gas to a liquid to a solid. Explain the relationships among evaporation, condensation, cooling, and warming.

**PS 9**
### Learning Objectives

<table>
<thead>
<tr>
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<th>UNDERSTAND (Essential Questions)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>✪ An object’s <strong>temperature</strong> is the measurement of its average molecular kinetic energy</td>
<td>✪ Why temperature plays an important role in almost all fields of science, including physics, chemistry, and biology</td>
<td>✪ Create a poem or song that tells how evaporation and condensation are interrelated</td>
</tr>
<tr>
<td>✪ Temperature increases as the energy of particle motion increases</td>
<td>✪ How an object's average molecular kinetic energy relates to its temperature</td>
<td>✪ Take the temperature of several different objects and discuss in terms of average molecular kinetic energy</td>
</tr>
<tr>
<td>✪ Energy is absorbed when a substance changes from solid to liquid to gas</td>
<td>✪ Why energy is absorbed when a substance changes from solid to liquid to gas</td>
<td>✪ Interview or research scientists from different fields to find out how temperature plays a role in their work</td>
</tr>
<tr>
<td>✪ Energy is released when a substance changes from gas to liquid to solid</td>
<td>✪ How energy is released when a substance changes from gas to liquid to solid</td>
<td>✪ Calculate the amount of energy absorbed or released from a substance</td>
</tr>
</tbody>
</table>
| ✪ **Evaporation** results from warming (energy absorption), and **condensation** from cooling (energy release) | ✪ How evaporation and condensation are interrelated                                          | • Non-phase change transfers: 
  \[(Q = m \, c \, \Delta T), \; \text{e.g., warm to cool water, etc.}\]
• Phase change transfers: 
  \[(Q = m \, L), \; \text{e.g., warm to frozen water, etc.}\] |
### Key topics in Introductory Physics

<table>
<thead>
<tr>
<th>HEAT AND HEAT TRANSFER</th>
</tr>
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</table>

#### RELATED STANDARDS

**P 3.4**

Explain the relationships among temperature changes in a substance, the amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance.

**PS 9**
### Learning Objectives

<table>
<thead>
<tr>
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<th>AND BE ABLE TO DO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specific heat</strong> is the measure of the heat energy required to raise the temperature of a given amount of a substance by one degree. A substance’s change in temperature is based on the amount of heat transferred—either released or absorbed—the mass of the substance, and the specific heat of the substance.</td>
<td><strong>How temperature plays an important role in determining the rate and extent to which chemical reactions occur</strong>. <strong>Why the human body has several elaborate mechanisms for maintaining its temperature at 37 degrees Celsius</strong>. <strong>How temperature and specific heat are not defined by the system size or the amount of material in the system: intensive vs extensive properties (More advanced)</strong>.</td>
<td><strong>Calculate the specific heat of different substances</strong>. <strong>Compare the specific heat capacity of land, water, and air, and hypothesize how specific heat capacities of each affects our climate system</strong>. <strong>Predict the human body’s specific heat capacity, based on comparisons with a specific capacity chart of common solids and liquids, and support their reasoning; then research the actual capacity and reformulate their reasoning</strong>. <strong>Experiment with varying temperatures as a catalyst in chemical reactions, either physically or virtual labs, and report findings</strong>. <strong>Compare and contrast intensive and extensive properties of an object or system, and how they relate to temperature (More advanced)</strong>.</td>
</tr>
</tbody>
</table>
### Key topics in Introductory Physics

| WAVES |

### RELATED STANDARDS

**P 4.1**

Describe the measurable properties of waves (velocity, frequency, wavelength, amplitude, period) and explain the relationships among them. Recognize examples of simple harmonic motion.
# Learning Objectives

<table>
<thead>
<tr>
<th>STUDENTS SHOULD KNOW</th>
<th>UNDERSTAND (Essential Questions)</th>
<th>AND BE ABLE TO DO</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ The measurable properties of waves, including velocity, frequency, wavelength, amplitude, period</td>
<td>▶ How longitudinal and transverse waves move.</td>
<td>▶ Within a specified period of time (~ five minutes), list numerous examples of waves experienced in our daily lives</td>
</tr>
<tr>
<td>▶ A wave is a displacement of particles</td>
<td>▶ Why alterations in a property of a wave (such as wavelength) will not affect the speed of the wave.</td>
<td>▶ As a whole group, list examples on the board and tally how many times each example was cited</td>
</tr>
<tr>
<td>▶ That there are two basic types of wave motion for mechanical waves: longitudinal waves and transverse waves</td>
<td>▶ How mechanical waves and electromagnetic waves are similar and different (refer to Standard P 4.2)</td>
<td>▶ Compare and contrast longitudinal and transverse waves using a concept map (refer to Standard P 4.3)</td>
</tr>
<tr>
<td>▶ Mechanical waves are propagated through a material medium (solid, liquid, or gas)</td>
<td>▶ How elasticity and inertia are important components of simple harmonic motion.</td>
<td>▶ Use the information to form a hypothesis about which kind of wave an ocean wave is</td>
</tr>
<tr>
<td>▶ The speed of a wave depends on the properties of the medium through which it travels</td>
<td>▶ How simple harmonic oscillators are useful in our everyday lives</td>
<td>▶ Create an experiment to test your hypothesis (or research the answer)</td>
</tr>
<tr>
<td>▶ Simple harmonic motion occurs when an object oscillates about a stable equilibrium position, and experiences a restoring force approximately described by Hooke’s Law</td>
<td></td>
<td>▶ Experiment with different mediums (liquid or solid) to observe the speed of waves, and compute the measurable properties of waves</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Identify differences between mechanical waves and electromagnetic waves by demonstrating an instance of each (refer to Standard P 4.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Create a simple harmonic wave and explain how the oscillator could be developed into a clock</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Develop a reasoned account and dialogue about why one type of wave (transverse or longitudinal) is more important than another</td>
</tr>
</tbody>
</table>

**AND BE ABLE TO DO**

- Compute measurable properties of waves
- Identify examples of simple harmonic oscillators (e.g., a mass attached to a spring, a molecule inside a solid, a car stuck in a ditch being "rocked out," and a pendulum)
<table>
<thead>
<tr>
<th>Key topics in Introductory Physics</th>
<th>RELATED STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTROMAGNETISM</td>
<td></td>
</tr>
</tbody>
</table>

**P 5.1**

Recognize that an electric charge tends to be static on insulators and can move on and in conductors. Explain that energy can produce a separation of charges.
### Learning Objectives

<table>
<thead>
<tr>
<th>STUDENTS SHOULD KNOW</th>
<th>UNDERSTAND (Essential Questions)</th>
<th>AND BE ABLE TO DO</th>
</tr>
</thead>
<tbody>
<tr>
<td>- That an <strong>electric charge</strong> tends to be static on <strong>insulators</strong></td>
<td>- Why insulators prevent the flow of electrical charge</td>
<td>- Identify conductors and insulators and how they are used beneficially in our daily lives; arrange the examples along a continuum to demonstrate how they are connected</td>
</tr>
<tr>
<td>- That an electric charge moves on and in <strong>conductors</strong></td>
<td>- How conductors allow the movement of electrical charges</td>
<td>- Separate charges in simple experiments (i.e., with balloons or combs), and explain how energy was used</td>
</tr>
<tr>
<td>- That energy can produce a separation of charges</td>
<td>- How we can use energy to separate charges</td>
<td>- Investigate other ways to collect and release static electricity</td>
</tr>
<tr>
<td>- A common misconception is that moving charges are exclusively negative</td>
<td>- How conductors can facilitate the flow of several types of electric charges, e.g., both negative and positive ions moving in opposite directions (<em>More advanced</em>)</td>
<td>- Figure out why there are no real practical uses of static electricity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Research and explain what amber (fossilized tree sap) has to do with electricity (<em>historical component</em>)</td>
</tr>
</tbody>
</table>
## Key topics in Introductory Physics

<table>
<thead>
<tr>
<th>ELECTROMAGNETISM</th>
<th>RELATED STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P 5.2</strong></td>
<td>Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm’s law).</td>
</tr>
<tr>
<td><strong>P 5.5</strong></td>
<td>Explain how electric current is a flow of charge caused by a potential difference (voltage), and how power is equal to current multiplied by voltage.</td>
</tr>
</tbody>
</table>
# Learning Objectives

<table>
<thead>
<tr>
<th>STUDENTS SHOULD KNOW</th>
<th>UNDERSTAND (Essential Questions)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>That Ohm’s Law defines the relationship between current, voltage, and resistance</td>
<td>How Ohm’s Law can be used to solve simple circuits</td>
<td>Use Ohm’s Law to solve simple circuit equations</td>
</tr>
<tr>
<td>Power is also a factor in the relationship between current, voltage, and resistance</td>
<td>The difference between current, voltage, resistance, and power</td>
<td>Demonstrate an understanding of Ohm’s Law by creating a simple circuit, either physically or in a virtual lab</td>
</tr>
<tr>
<td>Ohm’s Law is the foundation of electronics and electricity <em>(historical component)</em></td>
<td></td>
<td>Predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors</td>
</tr>
<tr>
<td>That electric current is a flow of charge caused by a potential difference <em>(voltage)</em></td>
<td>How electric companies make use of potential differences.</td>
<td>Calculate voltage, current, and power, showing how knowing any two quantities will allow one to figure out the quantity in question</td>
</tr>
<tr>
<td>That power equals current multiplied by voltage <em>(P = I x V)</em></td>
<td>Why we are able to create potential differences, given that same-sign charged particles repel one another and different-sign charged particles attract.</td>
<td>Create a diagram of how electric current flows from a power plant and eventually to a home or other building</td>
</tr>
<tr>
<td></td>
<td>Investigate and explain how certain fish, like electric eels, produce and discharge electricity; create a multimedia report on this question</td>
<td></td>
</tr>
</tbody>
</table>

That electric current is a flow of charge caused by a potential difference *(voltage)*

That power equals current multiplied by voltage *(P = I x V)*
**INTRODUCTORY PHYSICS**

**WHAT SHOULD STUDENTS KNOW?**

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<tbody>
<tr>
<td><strong>ELECTROMAGNETIC RADIATION</strong></td>
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</table>

**P 6.2**

Describe the electromagnetic spectrum in terms of frequency and wavelength, and identify the locations of radio waves, microwaves, infrared radiation, visible light (red, orange, yellow, green, blue, indigo, and violet), ultraviolet rays, x-rays, and gamma rays on the spectrum.
<table>
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<th>STUDENTS SHOULD KNOW</th>
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</thead>
<tbody>
<tr>
<td>• The <strong>electromagnetic spectrum</strong> is composed of radio waves, microwaves, infrared</td>
<td>• How high-frequency electromagnetic waves have a short wavelength and high energy, and low-frequency waves have a long wavelength and low energy</td>
<td>• Distinguish between the different types of electromagnetic waves and how each is present in our everyday lives</td>
</tr>
<tr>
<td>radiation, visible light (red, orange, yellow, green, blue, indigo, and violet),</td>
<td>• Why the electromagnetic spectrum is, in principle, infinite, extending beyond the limits of radio waves and gamma rays <em>(More advanced)</em></td>
<td>• Illustrate an electromagnetic spectrum with real world applications</td>
</tr>
<tr>
<td>ultraviolet waves, x-rays, and gamma rays</td>
<td></td>
<td>• Use a prism to demonstrate how white light is composed of constituent spectral colors</td>
</tr>
<tr>
<td>• Each category of the spectrum is based on frequency and wavelength</td>
<td></td>
<td>• Compare and contrast various instrumentation used to study deep space and the solar system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(examples include refracting telescopes, reflecting telescopes, radio telescopes, and spectro-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>photometers)</td>
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</tbody>
</table>
PROBLEM OF THE DAY

WORK & THE CONSERVATION OF ENERGY AND MOMENTUM

1 or 2 class periods

DEVELOPER'S NAME:
Deborah Foucault
dfoucault@collaborative.org

STRAND:
Introductory Physics

TOPIC:
Mechanical Work and the Conservation of Energy and Momentum

LEARNING OBJECTIVES:

By the end of this activity, students should

KNOW:

- Mechanical work is the amount of energy transferred by a force over distance: \( \text{work} = \text{force} \times \text{distance} \)
- The movement of an object must be in the direction of the force applied if work is to be done
- Mechanical energy is PART of an object's total energy
- Mechanical energy of an object/system includes its kinetic and potential energy, since they are easily subject to change by mechanical work
- Thermal and rest energy are forms of energy not typically included in an object’s total mechanical energy

UNDERSTAND:

- How humans can use, and machines can be used to do, mechanical work for numerous advantages
- Why energy can be used without work being done, but work cannot happen without energy
- Why kinetic and potential energy are easily changed by mechanical work, but thermal and rest energy are not (More advanced)

...and therefore be able to

DO

- Create an exemplar for future students (e.g., labeled diagram, written description, song, physical demonstration with explanation) of humans or machines engaged in the scientific definition of work
- Make observations, raise questions, and formulate hypotheses, both verbally and in writing (Standard SIS1)
- Work collaboratively to reach the objectives (5 Es)
- Think of work tasks accomplished during the day and list in order of the amount of work done; then explain reasoning
**P 2.3**
Describe both qualitatively and quantitatively how work can be expressed as a change in mechanical energy.

**PS 13**

**SIS1**
- Make observations, raise questions, and formulate hypotheses.
- Observe the world from a scientific perspective.
- Pose questions and form hypotheses based on personal observations, scientific articles, experiments, and knowledge.

- AGS *General Science*, pages 112-115
- white board and/or easel paper
- rulers (or folded paper if rulers are not allowed)
- homework handout
- paper
- colored pencils
- Koosh Ball
- markers

The teacher will toss a Koosh Ball out to a student and have the student throw it back. The teacher will then “try” to move a wall of the classroom, exerting a fair amount of force. As part of a pre-assessment, the teacher will ask the students, “Which example shows that work has been done?” and tally answers on the board ~ 5 minutes.

As a follow-up to tallying the responses, the teacher will pose the Essential Question/s to the whole group ~ 2 minutes.

**How can humans use their bodies advantageously to do mechanical work?** How can machines be used advantageously to do mechanical work?

Teacher will review the day's learning objectives (either reading them aloud or having students read different parts) ~ 5 minutes.

Students will formulate and write answers in pairs or small groups (teacher could assign either human or machine examples to different groups or pairs, or students could do both). The teacher will state how much time students have for this activity, and remind students half way through how much time is left ~ 5 minutes.

These Learning Objectives are tied to the following **LEARNING STANDARDS**
Students report their lists to the whole group, while the teacher or a student volunteer begins a group list on the white board or easel paper ~ 10 minutes

Reminding students of the “KNOW” objectives on the board, the teacher asks students to select an example of work from the group list that seems to meet some of these criteria (Teacher will highlight examples that meet criteria) ~5 minutes

Students will then use this example to create an exemplar for future students (e.g., labeled diagram, written description, song, physical demonstration with explanation) of humans or machines engaged in the scientific definition of work. Remind students to Engage, Explore, Explain, Elaborate/Extend, and Evaluate! Students’ exemplars will reference all “KNOW” components, including a testable calculation and a supported hypothesis about the most efficient means by which this work could be done (Students can work in teams, pairs, or individually) ~ 20 minutes

Wrap-up will consist of students writing a brief reflection on the most interesting element they learned today; students will hand in their reflections to the teacher ~ 5 minutes

**HOMEWORK**

**DIFFERENTIATION OF:**

**Product**

Choices include labeled diagrams, written descriptions, songs, or physical demonstrations with oral explanation

**Process**

Multiple student grouping options (individual, pairs, small and whole group) and multiple learning styles incorporated (e.g., kinesthetic—throwing the Kush Ball, pushing on the wall; auditory—oral communication; visual—viewing written components on board, the throwing of the Kush Ball and the pushing on the wall

**Content**

Lesson is centered around standards from high school physics and middle school physical science, with tasks scaffolded to allow all students to demonstrate their cognitive readiness levels via questions, answers, exemplars, and reflections. Math content includes tallying questions and creating a testable calculation.

**LESSON REFLECTION**

How do you know if the students accomplished the learning objectives for this lesson? If you were to repeat this lesson what would you adjust? What do you want or need to modify in the next lesson as a result of this lesson? Any other thoughts?
BACKGROUND FOR TEACHERS

Developed in 1987, the prototype of the Koosh was made out of rubber bands, and named “Koosh” because that's the sound it made when it landed. A rubber ball filled with a jelly-like plasma, the outside of the Koosh ball consisted of hundreds of rubber spikes—making it look like a soft flexible porcupine that did not hurt to hold or squeeze. When someone squeezed the object, the plasma caused it to squirm around in the hand, while the spikes provided something to grip.

Teachers might also create a short writing assignment or math activity that complement the use of the Koosh ball in this lesson.
ADDITIONAL RESOURCES
ADDITIONAL RESOURCES

IS WHAT YOU NEED ON THE SHELF?
Overview of additional resources provided to DYS program sites

IS WHAT YOU NEED ON THE WEB?
Brief introduction to web-based search techniques

GENERAL SCIENCE RESOURCES

GENERAL BIOLOGY RESOURCES

RESOURCES for teaching BIOCHEMISTRY

RESOURCES for teaching CELL BIOLOGY

RESOURCES for teaching GENETICS

RESOURCES for teaching ANATOMY & PHYSIOLOGY

RESOURCES for teaching EVOLUTION

RESOURCES for teaching ECOLOGY

RESOURCES for teaching CHEMISTRY

RESOURCES for teaching PHYSICS

TEACHERS’ FAVORITE RESOURCES
IS WHAT YOU NEED ON THE SHELF?

DYS programs have been provided with a variety of additional resources based on specifics needs and/or interests at each site. Some of these include *Biologica* CD, CyberEd, and other Virtual Lab software and information. Programs have also been provided with a number of hands-on science materials such as microscopes and owl pellet kits.

Additionally, DYS teachers will receive a number of print resources from the **Dr. Birdley Teaches Science** series developed by Nevin Katz. Titles in this series are referenced in the resource grids that follow. Each book in this series makes science content accessible and interesting to a wide range of students, using “Dr. Birdley” (a cartoon personality) to introduce key science concepts and vocabulary. These books include reproducible student activity pages, background information, study questions, graphic organizers, and quizzes.

There are a great many resources available in the DYS system that have not been directly addressed in this chapter. Please refer to instructional coaches or teaching coordinators for more information about additional resources that may address the needs of your students.

Please note that not every DYS site will have received every resource or material that is listed in this guide. If you are unable to find a specific resources that you think would be of particular value in your classroom, teachers should feel free to ask their teaching coordinators or instructional coaches for assistance in locating a copy.
SEARCHING THE WEB for GOOD INFORMATION

To learn about up-to-the-minute research, practices, and resources for teaching science to young people whose life circumstances place them “at risk,” teachers may wish to conduct a web-based search on Google or Dogpile, or any other large search engine. It will be useful to focus on specific terms such as, “education,” “practices,” “at-risk,” “science,” “literacy,” “adolescent,” “chemistry,” etc. Additionally, generic search engines like About.com and Wikipedia can be quite helpful in finding basic or general information on science topics.

When the results of such a web-based search are overly broad—or simply overwhelming in number—a “Boolean search” can be extremely helpful. Such a search uses the common words, AND, OR, and NOT in combination with your own search terms. These common words, known as “Boolean operators,” instruct the search engine to narrow or refine your results by showing only those outcomes that combine your search terms in the ways that you have specified. For example, a Boolean search for “science AND learning objectives” or “biology AND language objectives” would yield many valuable links and a good deal of useful information, while screening out resources about learning or language objectives that are more general and might not lead to content-specific material.

When you find pages that you consider useful, consider using a “website copier” to save the pages as well as all of their links, onto your computer’s hard drive. This technique, which is sometimes called “web-wacking,” will enable students to interact with and use the internet sites you select—without actually being on the web! Go to www.httrack.com/ for a free website copier that will help you save your favorite internet resources for future use.
## GENERAL SCIENCE

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<th>Where to find it</th>
<th>How to use it</th>
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<td><strong>Resources in Print</strong></td>
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</tbody>
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<table>
<thead>
<tr>
<th>Book Title</th>
<th>Author(s)</th>
<th>Publisher</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGS General Science</td>
<td>Marshall, R. H., Jacobs, D. H., Rosskopf, A. B., and LaRue, C. J.</td>
<td>AGS Publishing</td>
<td>Introduces students to basic scientific concepts and principles presented in easily manageable segments. Content is supported with expanded real-world activities, test preparation, and reviews.</td>
</tr>
<tr>
<td>Top Shelf Forensics</td>
<td>Portland, Maine: Walch Publishing (2003).</td>
<td></td>
<td>A laboratory resource that mimics crime scene investigations and adheres to National Science Education Standards</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Myth-Busting on the Web</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific misconceptions are barriers to understanding</td>
</tr>
<tr>
<td>Ten Myths of Science (what we think we know)</td>
</tr>
<tr>
<td>An important component of teaching science is helping students avoid or eliminate misconceptions</td>
</tr>
<tr>
<td>GENERAL SCIENCE</td>
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<tr>
<td>Houghton Mifflin Science DiscoveryWorks</td>
</tr>
<tr>
<td>Reach Out! Michigan</td>
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<tr>
<td>National Science Digital Library</td>
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<td>PBS Innovations</td>
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<tr>
<td>Exploratorium</td>
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<tr>
<td>Environmental Health Perspective</td>
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<tr>
<td>The Gene School</td>
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<tr>
<td>Brain POP</td>
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<tr>
<td>Spark Notes</td>
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</tbody>
</table>
### Resources in Print

| Biology: Cycles of Life (AGS) | All of these biology texts have recently been purchased and distributed to DYS programs. If you are unable to locate one or more of these resources, please ask your instructional coach and/or the Program Director at your facility for assistance in locating a copy. |
| Success in Science: Basic Biology | |
| Daybook Life Science | |
| Basic Biology | |
| Human Biology Activity Book | |
| Biology: The Easy Way | |
| Essential Biology | |

### Resources on the Web

| What is Life? | http://whatislife.com/principles/principles.htm | Overview of basic biological information |
| The Biology Project | www.biology.arizona.edu | Online Interactive Resource for Learning Biology. Great resources for teachers looking for a brief review of the material |
| Staples High School Science Department Biology Website | http://shs.westport.k12.ct.us/mjvl/science/bioweb.htm | Great sites for accessing additional Biology resources! |
| Mrs. Muskopf’s Biology Website, Granite City High School | http://www.biologycorner.com/bio1/ | (Note: looking at other schools’ and teachers’ websites can be a great way to locate resources and activities for all subjects and levels) |
| Access Excellence at the National Health Museum | http://www.accessexcellence.org/ | Archive of favorite classroom activities submitted by high school biology and life sciences teachers in the Access Excellence programs |
| BioEd Online: Biology Teacher Resources from Baylor College of Medicine | http://www.bioedonline.org/resources/nsbri.cfm | Can search for informational slides on various biology topics and for other teacher resources |
| Misconceptions in Biology | http://departments.weber.edu/sciencecenter/biology%20misconceptions.htm | An important component of teaching science is helping students avoid or eliminate misconceptions |
## BIOCHEMISTRY (Standards B 1.1-B 1.3)

<table>
<thead>
<tr>
<th>Resources in Print</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dr. Birdley Teaches Science: Atomic Structure And Chemical Reactions</strong></td>
</tr>
<tr>
<td>Recently purchased and distributed to DYS programs; please ask your instructional coach and/or Program Director for help locating a copy</td>
</tr>
<tr>
<td>In this title, the “Dr. Birdley” cartoon personality introduces key concepts and vocabulary for biochemistry and chemical reactions</td>
</tr>
</tbody>
</table>

## Resources on the Web

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Life Chemistry</strong></td>
</tr>
<tr>
<td><a href="http://www.greenspirit.org.uk/resources/LifeChemistry.htm">http://www.greenspirit.org.uk/resources/LifeChemistry.htm</a></td>
</tr>
<tr>
<td>Brief overview of chemical compounds found in living things</td>
</tr>
<tr>
<td><strong>What is Life?</strong></td>
</tr>
<tr>
<td><a href="http://www.whatislife.com/principles/principles03-chemistry.htm">http://www.whatislife.com/principles/principles03-chemistry.htm</a></td>
</tr>
<tr>
<td>What is Life—principles in biology</td>
</tr>
<tr>
<td><strong>Interactive Concepts in Biochemistry</strong></td>
</tr>
<tr>
<td><a href="http://www.wiley.com/legacy/college/boyer/0470003790/">http://www.wiley.com/legacy/college/boyer/0470003790/</a></td>
</tr>
<tr>
<td>Dynamic resources designed to supplement and extend the critical concepts presented in Boyer’s textbook, <em>Concepts in Biochemistry</em>; can also be used in conjunction with other biochemistry lessons</td>
</tr>
<tr>
<td><strong>Institute of Food Technologists</strong></td>
</tr>
<tr>
<td><a href="http://members.ift.org/IFT/Education/TeacherResources/">http://members.ift.org/IFT/Education/TeacherResources/</a></td>
</tr>
<tr>
<td>Discusses how organic molecules can be tied to nutrition</td>
</tr>
<tr>
<td><strong>Reciprocal Net: a crystallography network for researchers, students and the general public (More Advanced)</strong></td>
</tr>
<tr>
<td>Interesting site; provides detailed overviews of a vast array of biochemical macromolecules</td>
</tr>
<tr>
<td><strong>Ask-a-Biologist: Building Blocks of Life</strong></td>
</tr>
<tr>
<td><a href="http://askabiologist.asu.edu/research/buildingblocks/index.html">http://askabiologist.asu.edu/research/buildingblocks/index.html</a></td>
</tr>
<tr>
<td>Discusses the “building blocks of life” (Note: this site is also a useful resource for teaching Cell Biology)</td>
</tr>
<tr>
<td>CELL BIOLOGY (Standards B 2.1-B 2.8)</td>
</tr>
<tr>
<td>-------------------------------------</td>
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<tr>
<td><strong>Resources in Print</strong></td>
</tr>
<tr>
<td><strong>Dr, Birdley Teaches Science:</strong></td>
</tr>
<tr>
<td><em>Introducing Cells</em></td>
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<tr>
<td><strong>Dr, Birdley Teaches Science:</strong></td>
</tr>
<tr>
<td><em>Parts of the Cell</em></td>
</tr>
<tr>
<td><strong>Dr, Birdley Teaches Science:</strong></td>
</tr>
<tr>
<td><em>Classifying Cells</em></td>
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</tbody>
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| **CELL BIOLOGY**  
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</tr>
<tr>
<td>The Virtual Cell</td>
<td><a href="http://www.ibiblio.org/virtualcell/index.htm">http://www.ibiblio.org/virtualcell/index.htm</a></td>
<td>Great interactive site that explains cells parts and their functions</td>
</tr>
<tr>
<td>CELLS Alive!</td>
<td><a href="http://www.cellsalive.com/">http://www.cellsalive.com/</a></td>
<td>Interactive overview of cells, organelles, mitosis, meiosis, and the cell cycle</td>
</tr>
<tr>
<td>Build a Cell</td>
<td><a href="http://www.bioscope.org/taste/builda.htm">http://www.bioscope.org/taste/builda.htm</a></td>
<td>Another great interactive site that explains cells parts and their functions</td>
</tr>
<tr>
<td>Cells &amp; Evolution of Life</td>
<td><a href="http://www.sci.uidaho.edu/bionet/biol115/">http://www.sci.uidaho.edu/bionet/biol115/</a></td>
<td>Interactive cell available</td>
</tr>
<tr>
<td>How Cells Work</td>
<td><a href="http://science.howstuffworks.com/cell.hrm">http://science.howstuffworks.com/cell.hrm</a></td>
<td>Overview of cells in printable form includes enzymes, proteins, DNA, genetic diseases, and other topics</td>
</tr>
<tr>
<td>Ask-a-Biologist: Building Blocks of Life</td>
<td><a href="http://askabiologist.asu.edu/search/buildingblocks/index.html">http://askabiologist.asu.edu/search/buildingblocks/index.html</a></td>
<td>Discussion of the “building blocks of life,” including definitions of terms (such as cell, proteins, lipids, etc) and an overview of the cell organelles</td>
</tr>
<tr>
<td>Cell Biology Animation</td>
<td><a href="http://www.johnkyrk.com/index.html">http://www.johnkyrk.com/index.html</a></td>
<td>Great animated displays of cell function, anatomy, organelles, DNA functions, Krebs Cycle, meiosis and mitosis, and photosynthesis. Graphics suit all levels; text may be more advanced</td>
</tr>
<tr>
<td>General Bio 101</td>
<td><a href="http://bio.rutgers.edu/~gb101/virtual-labs_101.html">http://bio.rutgers.edu/~gb101/virtual-labs_101.html</a></td>
<td>Interactive virtual laboratories that do not require any materials</td>
</tr>
<tr>
<td>Cell biology topics (More Advanced)</td>
<td><a href="http://cellbio.utmb.edu/cellbio/">http://cellbio.utmb.edu/cellbio/</a></td>
<td>Great drawings and detailed descriptions of stages of biological processes that occur in the cell</td>
</tr>
<tr>
<td>Videos of <em>C. elegans</em> (worm) development (More Advanced)</td>
<td><a href="http://www.bio.unc.edu/faculty/Goldstein/lab/movies.html">www.bio.unc.edu/faculty/Goldstein/lab/movies.html</a></td>
<td>Links to timelapse films made by <em>C. elegans</em> researchers, including footage of cells undergoing mitosis</td>
</tr>
</tbody>
</table>
| GENETICS  
(Standards B 3.1-B 3.6) | Where to find it | How to use it |
<table>
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<tr>
<td><strong>Resources on the Web</strong></td>
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</table>

<p>| DNA From the Beginning | <a href="http://www.dnaftb.org/dnaftb/">http://www.dnaftb.org/dnaftb/</a> | Overview of genetics: dominant/recessive genes, gametes, chromosomes, inheritance, Mendelian laws, DNA, proteins, RNA, mutations. Includes great animated tutorials! |
| Genetic Science Learning Center at the University of Utah | <a href="http://learn.genetics.utah.edu/misc/glossary">http://learn.genetics.utah.edu/misc/glossary</a> | Extensive glossary of terms from genetics, presented in an interactive style |
| The Gene Scene | <a href="http://www.ology.amnh.org/genetics/index.html">http://www.ology.amnh.org/genetics/index.html</a> | The American Museum of Natural History’s website features easy-to-read stories on genetics and terrific animations |
| How Stuff Works: Overview of DNA | <a href="http://science.howstuffworks.com/dna.htm">http://science.howstuffworks.com/dna.htm</a> | Overview of DNA in a written, printable format |
| DNA Interactive | <a href="http://www.dnai.org/index.html">http://www.dnai.org/index.html</a> | Overview of DNA with computer-generated videos and interactive explanatory activities |
| The Gene School | <a href="http://library.thinkquest.org/19037/general_info.html">http://library.thinkquest.org/19037/general_info.html</a> | Basic info about genes including a timeline of the discovery of DNA, with general science resources and links also available |
| Genetic Lesson Plan Ideas | <a href="http://www.kumc.edu/gec/lessons.html">http://www.kumc.edu/gec/lessons.html</a> | Great links provided to a variety of web-based teacher resources |
| About.com: Basic Principles of Genetics | <a href="http://biology.about.com/gi/dynamic/offsite.htm?zi=1/XJ&amp;sdn=biology&amp;zu=http%3A%2F%2Fanthro.palomar.edu%2Fmendel%2Fdefault.htm">http://biology.about.com/gi/dynamic/offsite.htm?zi=1/XJ&amp;sdn=biology&amp;zu=http%3A%2F%2Fanthro.palomar.edu%2Fmendel%2Fdefault.htm</a> | Great site for students and teachers, filled with basic information on genetics. Given the length of the URL, however, it may be easier to go to about.com and enter various search terms to see what entries or combinations of terms you find most helpful |</p>
<table>
<thead>
<tr>
<th>Resource Name</th>
<th>URL</th>
<th>Description</th>
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<tbody>
<tr>
<td>Interactive Human Body</td>
<td><a href="http://www.bbc.co.uk/science/human-body/body/interactives/3djigsaw_02/">http://www.bbc.co.uk/science/human-body/body/interactives/3djigsaw_02/</a></td>
<td>The first site is an interactive practice program that covers the four anatomical systems: organs, muscles, skeleton, and nervous system.</td>
</tr>
<tr>
<td>BBC’s Science &amp; Nature: Human Body &amp; Mind</td>
<td><a href="http://www.bbc.co.uk/science/human-body/body/">http://www.bbc.co.uk/science/human-body/body/</a></td>
<td>Coupled with the practice program, the second site, which includes detailed diagrams, covers the main items of each of the systems of the human body.</td>
</tr>
<tr>
<td>Human Anatomy Online</td>
<td><a href="http://www.innerbody.com">http://www.innerbody.com</a></td>
<td>A more in-depth look at human anatomy systems. Highly visual menu provides interest and ease of access.</td>
</tr>
<tr>
<td>Bloomington High School’s Advanced Biology Website</td>
<td><a href="http://www.biology87.org/">http://www.biology87.org/</a></td>
<td>Covers anatomical systems, including possible activities. Overview of the immune system and how it functions is included. Also, various documents covering all parts of biology curriculum.</td>
</tr>
<tr>
<td>Get Body Smart (More Advanced)</td>
<td><a href="http://www.getbodysmart.com/">http://www.getbodysmart.com/</a></td>
<td>Shows great detailed graphics of various body organs and their parts for all systems.</td>
</tr>
<tr>
<td>Pick a Bone (More Advanced)</td>
<td><a href="http://www.meddean.luc.edu/lumen/MedEd/GrossAnatomy/learnem/bones/main_bone.htm">http://www.meddean.luc.edu/lumen/MedEd/GrossAnatomy/learnem/bones/main_bone.htm</a></td>
<td>Learn more about the shape and parts of specific bones in the body.</td>
</tr>
<tr>
<td>Website for Human Anatomy and Physiology (More Advanced)</td>
<td><a href="http://bioweb.uwlax.edu/APlab/Table_of_Contents/table_of_contents.html">http://bioweb.uwlax.edu/APlab/Table_of_Contents/table_of_contents.html</a></td>
<td>Provides great cross sections of various body parts that would typically be studied in an anatomy and physiology lab.</td>
</tr>
<tr>
<td>About.com: Online Dissections</td>
<td><a href="http://biology.about.com/od/onlinedissections/a/aa112805a.htm">http://biology.about.com/od/onlinedissections/a/aa112805a.htm</a></td>
<td>Links to various online dissections including a cow’s eye, frog, fetal pig, and cat.</td>
</tr>
<tr>
<td><strong>EVOLUTION</strong> (Standards B 5.1-B 5.3)</td>
<td><strong>Where to find it</strong></td>
<td><strong>How to use it</strong></td>
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<tr>
<td><strong>Cells and the Evolution of Life</strong></td>
<td><a href="http://www.sci.uidaho.edu/bionet/biol115/">http://www.sci.uidaho.edu/bionet/biol115/</a></td>
<td>Outlines the interconnectedness of various parts of biology (genetics, energy, etc.) through evolution, with links to more advanced content</td>
</tr>
<tr>
<td><strong>Understanding Evolution: Evolution 101</strong></td>
<td><a href="http://evolution.berkeley.edu/evolibrary/article/evo_01">http://evolution.berkeley.edu/evolibrary/article/evo_01</a></td>
<td>General but well-detailed overview of evolution, its processes, and the role of natural selection and genetics</td>
</tr>
<tr>
<td><strong>Understanding Evolution: History of Evolutionary Thought</strong></td>
<td><a href="http://evolution.berkeley.edu/evolibrary/article/0_0_0/history_index_02">http://evolution.berkeley.edu/evolibrary/article/0_0_0/history_index_02</a></td>
<td>More complete overview of the development of evolutionary theory and people involved in its formulation</td>
</tr>
<tr>
<td><strong>American Museum of Natural History: Charles Darwin Exhibit</strong></td>
<td><a href="http://www.amnh.org/exhibitions/darwin/">http://www.amnh.org/exhibitions/darwin/</a></td>
<td>Outlines the life of Charles Darwin and his discovery of the principles of natural selection</td>
</tr>
<tr>
<td><strong>How Stuff Works: Evolution</strong></td>
<td><a href="http://science.howstuffworks.com/evolution.htm">http://science.howstuffworks.com/evolution.htm</a></td>
<td>Overview of the process of evolution</td>
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</table>
## Resources on the Web

| **ECOLOGY**  
<table>
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<tr>
<th>(Standards B 6.1-B 6.4)</th>
<th><strong>Where to find it</strong></th>
<th><strong>How to use it</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Introduction to Biomes</strong></td>
<td>[<a href="http://leda.calstatela.edu/courses">http://leda.calstatela.edu/courses</a> builders/lessons/less/biomes/introbiomes.html](<a href="http://leda.calstatela.edu/courses">http://leda.calstatela.edu/courses</a> builders/lessons/less/biomes/introbiomes.html)</td>
<td>Information on multiple biomes and their food webs, as well as discussions on carrying capacities, dominance hierarchies, and reproductive strategies.</td>
</tr>
<tr>
<td><strong>Saving Our Environment: Introduction to Pollution</strong></td>
<td><a href="http://library.thinkquest.org/C0111401/learn_pollution.htm">http://library.thinkquest.org/C0111401/learn_pollution.htm</a></td>
<td>Overview of land, air, and water pollution and their effects.</td>
</tr>
<tr>
<td><strong>Cycling through the Food Web (More Advanced)</strong></td>
<td><a href="http://www.bigelow.org/bacteria/">http://www.bigelow.org/bacteria/</a></td>
<td>Information about energy and carbon flow in ecosystems. <em>(Note: Reading level may be more advanced for some students)</em></td>
</tr>
</tbody>
</table>
## Resources in Print

<table>
<thead>
<tr>
<th>CHEMISTRY</th>
<th>Where to find it</th>
<th>How to use it</th>
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</thead>
<tbody>
<tr>
<td><strong>AGS Biology: Cycles of Life</strong></td>
<td>Chapter 2 of the primary Biology text</td>
<td>Biology and Chemistry</td>
</tr>
<tr>
<td><strong>Dr, Birdley Teaches Science: Atomic Structure And Chemical Reactions</strong></td>
<td>Recently purchased and distributed to DYS programs; please ask your instructional coach and/or Program Director for help locating a copy</td>
<td>Biochemistry and Chemistry</td>
</tr>
<tr>
<td><strong>Dr, Birdley Teaches Science: Elements, Compounds, And Mixtures</strong></td>
<td></td>
<td>Chemistry</td>
</tr>
<tr>
<td><strong>Dr, Birdley Teaches Science: Properties Of Matter</strong></td>
<td></td>
<td>Chemistry</td>
</tr>
<tr>
<td><strong>Elements and the Periodic Table</strong></td>
<td>Abbgy, T. (2001). USA: Mark Twain Media, Inc.</td>
<td>Chemistry Standards C 3.1 and 3.2</td>
</tr>
<tr>
<td><strong>Chemistry Activities for Grades 5-12.</strong></td>
<td>Handwerker, M. J. (1999) West Nyack: Center for Applied Research in Education.</td>
<td>Great resources for chemistry activities appropriate for grades 5-12</td>
</tr>
<tr>
<td><strong>Hands-on Chemistry Activities with Real Life Applications</strong></td>
<td>Cunningham, J. &amp; Herr, N. (1999) San Francisco:Jossey-Bass. (More Advanced)</td>
<td>Great hands-on activities for grades 8-12. Requires chemicals that may not be available in most DYS settings</td>
</tr>
<tr>
<td><strong>Success in Science: Basic Chemistry</strong></td>
<td>Globe Fearon</td>
<td>Second part of the two-part Success in Science series</td>
</tr>
<tr>
<td><strong>CHEMISTRY</strong></td>
<td><strong>Where to find it</strong></td>
<td><strong>How to use it</strong></td>
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<tr>
<td>★ Mr. Rapp’s Chemistry Help Site ★</td>
<td><a href="http://www.chemistrygeek.com">www.chemistrygeek.com</a></td>
<td>Study guides, notes, practice problems and worksheets for various levels on all chemistry topics</td>
</tr>
<tr>
<td>Web-Based High School Chemistry Simulations</td>
<td><a href="http://cse.edc.org/products/simulations/catalog.asp">http://cse.edc.org/products/simulations/catalog.asp</a></td>
<td>Excellent links to other great chemistry sites!</td>
</tr>
<tr>
<td>General Chemistry Demos</td>
<td><a href="http://genchem.chem.wisc.edu/demonstrations/General_Chemistry_Demos.html">http://genchem.chem.wisc.edu/demonstrations/General_Chemistry_Demos.html</a></td>
<td>Online videos of demos with brief descriptions</td>
</tr>
<tr>
<td>JCE High School Chemed Learning Information Center (CLIC)</td>
<td><a href="http://jchemed.chem.wisc.edu/HS/index.html">http://jchemed.chem.wisc.edu/HS/index.html</a></td>
<td>Resources from the <em>Journal of Chemical Education</em> of interest to high school chemistry teachers. PDFs of a variety of classroom activities available!</td>
</tr>
<tr>
<td>Chemistry Explorer Dictionary</td>
<td><a href="http://www.webref.org/chemistry/chemistry.htm">http://www.webref.org/chemistry/chemistry.htm</a></td>
<td>Comprehensive dictionary of chemistry terms</td>
</tr>
<tr>
<td>Chemistry Internet Resources for High School Students</td>
<td><a href="http://www.canby.com/hemphill/chmfrm.html">http://www.canby.com/hemphill/chmfrm.html</a></td>
<td>Great site with additional chemistry resources for high school level students</td>
</tr>
<tr>
<td>Lenntech Water Purification and Air Treatment</td>
<td><a href="http://www.lenntech.com/periodic-chart.htm">http://www.lenntech.com/periodic-chart.htm</a></td>
<td>Great library with links to an interactive periodic table. Find instant information on each element. Also provides great information on how chemistry is used in water purification and air treatment</td>
</tr>
<tr>
<td>Misconceptions in Chemistry</td>
<td><a href="http://educ.queensu.ca/~science/main/concept/chem/c07/C07CDTL1.htm">http://educ.queensu.ca/~science/main/concept/chem/c07/C07CDTL1.htm</a></td>
<td>An important component of teaching science is helping students avoid or eliminate misconceptions</td>
</tr>
</tbody>
</table>
## More advanced Resources on the Web

<table>
<thead>
<tr>
<th>CHEMISTRY</th>
<th>Where to find it</th>
<th>How to use it</th>
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</thead>
<tbody>
<tr>
<td>ChemiCool Website</td>
<td><a href="http://www.chemicool.com/">http://www.chemicool.com/</a></td>
<td>Resources include the periodic table, unit conversion calculator, and a chemistry dictionary</td>
</tr>
<tr>
<td>Advanced Chemistry Development Website</td>
<td><a href="http://www.acdlabs.com/download/">http://www.acdlabs.com/download/</a></td>
<td>Free software downloads include ChemSketch, which allows you to draw lab equipment, structures, etc. <em>at no cost!</em></td>
</tr>
<tr>
<td>Molecular Visualization Resources</td>
<td><a href="http://www.umass.edu/microbio/chime/">http://www.umass.edu/microbio/chime/</a></td>
<td>Biology Standard B 1.2 and Chemistry Cool collection of synthesized images of various molecules</td>
</tr>
<tr>
<td>The ChemCollective: Online Resources for Teaching and Learning Chemistry (More Advanced)</td>
<td><a href="http://www.chemcollective.org/tutorials.php">http://www.chemcollective.org/tutorials.php</a></td>
<td>Overview of chemistry principles includes interactive virtual labs as well as short animations. Text versions of the movies available for easy review</td>
</tr>
<tr>
<td>The ChemTeam (More Advanced)</td>
<td><a href="http://dbhs.wvusd.k12.ca.us/web-docs/ChemTeamIndex.html">http://dbhs.wvusd.k12.ca.us/web-docs/ChemTeamIndex.html</a></td>
<td>Study resources in all standard topics for students in HS and AP chemistry</td>
</tr>
<tr>
<td>General Chemistry Online! (More Advanced)</td>
<td><a href="http://antoine.frostburg.edu/chem/senese/101/index.shtml">http://antoine.frostburg.edu/chem/senese/101/index.shtml</a></td>
<td>Notes available, kits for practicing balancing chemical equations, unit conversions, and ionic compounds; provides a periodic table, a graphic function, and a calculator for solving “gas law” problems</td>
</tr>
<tr>
<td><strong>PHYSICS</strong></td>
<td><strong>Where to find it</strong></td>
<td><strong>How to use it</strong></td>
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<tr>
<td>Stop Faking It! Finally Understanding Science So You Can Teach It Series</td>
<td>Robertson, William C. (2003). National Science Teachers Association Press</td>
<td>Extensive series addresses electricity and magnetism, energy, force and motion, and more!</td>
</tr>
<tr>
<td>AGS Physical Science Video Series Physical Science Video Quiz Series Thrilling Experiments Video Series</td>
<td>Engage students with videos</td>
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<tr>
<td><strong>PHYSICS</strong></td>
<td><strong>Where to find it</strong></td>
<td><strong>How to use it</strong></td>
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<tr>
<td>The Physics Classroom</td>
<td><a href="http://www.physicsclassroom.com">http://www.physicsclassroom.com</a></td>
<td>Detailed tutorial on all aspects of general physics. Complete overview of high school physics, including practice problems and visualizations</td>
</tr>
<tr>
<td>The Physics Department</td>
<td><a href="http://id.mind.net/~zona/mstm/physics/physics.html">http://id.mind.net/~zona/mstm/physics/physics.html</a></td>
<td>Highly visual site with adequate instruction and in-depth description that makes use of interactive displays of physics concepts</td>
</tr>
<tr>
<td>The Ultimate Physics Resource Site</td>
<td><a href="http://serendip.brynmawr.edu/local/IIT/projects/Glasser.html">http://serendip.brynmawr.edu/local/IIT/projects/Glasser.html</a></td>
<td>“Jump site” with links to fun physics activities, physicists, research labs, and other resources for answers to physics questions</td>
</tr>
<tr>
<td>Secondary Education Physics</td>
<td><a href="http://www.pitt.edu/~poole/physics.html">http://www.pitt.edu/~poole/physics.html</a></td>
<td>Vast collection of secondary education resources</td>
</tr>
<tr>
<td>“Why Study Physics?”</td>
<td><a href="http://www.aps.org/studentsandeducators/index.cfm">http://www.aps.org/studentsandeducators/index.cfm</a></td>
<td>Nice overview of physics applications and educational resources</td>
</tr>
<tr>
<td>Animations</td>
<td><a href="http://www.physics-animations.com/">http://www.physics-animations.com/</a></td>
<td>Includes well-made animations of physics principles (<em>Note: some parts include advanced material that is unnecessary for high school physics</em>)</td>
</tr>
<tr>
<td>Experiments</td>
<td><a href="http://physicslessons.com/iphysics.htm">http://physicslessons.com/iphysics.htm</a></td>
<td>Online interactive experiments that allow the user to manipulate various factors to understand concepts</td>
</tr>
<tr>
<td>Demonstrations</td>
<td><a href="http://www.walter-fendt.de/ph14e/">http://www.walter-fendt.de/ph14e/</a></td>
<td>Extensive demonstrations of physics</td>
</tr>
<tr>
<td>Misconceptions in Physics</td>
<td><a href="http://phys.udallas.edu/C3P/Preconceptions.pdf">http://phys.udallas.edu/C3P/Preconceptions.pdf</a></td>
<td>An important component of teaching science is helping students avoid or eliminate misconceptions</td>
</tr>
</tbody>
</table>
Please remember that not every site will have received every resource or material that is listed in this guide. There are multiple resources available in the DYS system that have not been directly addressed in this chapter, and teachers should ask their teaching coordinators or instructional coaches for more information about specific resources that may be of particular interest.

In addition to the resources referenced in this chapter, there are many other strong resources to discover, consider, and use. The following pages offer space for teachers to record and make notes about additional resources they have found useful in their teaching.

For fun and edification—a cartoon from the Public Library of Science (PLOS), a nonprofit organization of scientists and physicians committed to making the world's scientific and medical literature freely available to the public.

www.plos.org
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<tr>
<th>Resource</th>
<th>Where you found it</th>
<th>How you use it</th>
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BALANCED ASSESSMENT—ONE SIZE DOES NOT FIT ALL
ASKING QUESTIONS WITH BLOOM’S TAXONOMY
ASSESSING STUDENT PROGRESS IN MEETING THE LEARNING OBJECTIVES
DEFINING ASSESSMENT
USING RUBRICS FOR AUTHENTIC ASSESSMENT
LOOKING AT STUDENT WORK—MCAS ASSESSMENTS AND RUBRICS
CREATING AND FINDING ASSESSMENTS AND RUBRICS ONLINE
teaching in DYS schools
BALANCED ASSESSMENT—ONE SIZE DOES NOT FIT ALL

In DYS settings, balanced assessment means that teachers gather information about students’ learning progress throughout the instructional process, and in a variety of ways. Recognizing that “one size does not fit all,” teachers differentiate their assessment approaches to meet the needs of students with diverse learning styles, multiple intelligence preferences, and other considerations.

On an ongoing basis, teachers’ **formative assessment** techniques include asking questions, (verbally or on worksheets), observing students during work sessions and activities, creating “ticket to leave /exit card” activities, giving quizzes, and assigning journal entries.

At the end of each mini-unit, teachers gather comprehensive data about students' progress relative to the learning objectives of the unit. These **summative assessment** activities may include performance tasks, projects, or comprehensive tests, and are commonly used to make a final evaluation of student progress for transcripts. (More detail about formative and summative assessments is provided later in this chapter.)

**FEATURES OF BALANCED ASSESSMENT**

Recognizing the diversity of the student population, teachers provide flexibility in the assessment process to allow students to demonstrate their knowledge and understanding in a variety of ways.

Learning objectives for the mini-unit or lesson are clearly communicated to students; students know what we want them to Know, Understand, and be able to Do.

Teachers use a range of assessment tools to monitor (formative assessment) and evaluate (summative assessment) students’ progress.

Reflective processes and activities include self-reflection, peer coaching, journals, logs, and self-critiques.

Tests and quizzes include a variety of response types including true/false or multiple choice selections, as well as responses that students must develop themselves, such as problems to solve, short answer, open-response or performance tasks.

Prompts that involve verbs from higher-level thinking processes (outlined in Bloom’s Taxonomy see next page), with an emphasis on evaluating, creating, applying, and analyzing, are used for culminating performances or other complex assessment projects.

Student portfolios are used to collect student work as a form of assessment, with key pieces of work selected by the students to meet established criteria for evaluation or to demonstrate progress.

Because different students show what they know and can do in different ways, assessments should also be conducted in multiple ways.

—NCTM Assessment Principle
ASKING QUESTIONS WITH BLOOM’S TAXONOMY

For more than 50 years, Bloom’s “Taxonomy of Educational Objectives” has been used as a valuable tool to organize educational goals and promote higher-order thinking. The taxonomy classifies six levels of qualitatively different thinking processes, with different kinds of thinking organized in a clear hierarchy. One end of the classification is considered basic thinking skills (factual or topical knowledge and retrieval), while the other end comprises higher-level thinking skills (conceptual understanding needed for critical thinking and problem-solving).

While Benjamin Bloom’s name was alphabetically first in a list of experts who developed this classification, many college and university professors participated jointly in developing what is now known as Bloom’s Taxonomy.

In the 1990’s, a former student of Bloom’s named Lorin Anderson led a team of cognitive psychologists in reviewing and revising the original taxonomy. To reflect the active nature of thinking, the name of each category of thinking was changed, and some categories were renamed to reflect the quality of these thinking processes.

Classifications in both the original and revised taxonomies are useful in asking questions and developing assignments that promote higher-order thinking. Using this taxonomy helps teachers assess student progress in ways that are grounded in different thinking processes.

Teachers use “prompts” from Bloom’s Taxonomy to assess the level or degree to which students grasp the material. The following examples illustrate this concept by focusing on the learning objective “To Comprehend and Use Science Concepts and Skills in Real-World Situations.”

- **Recognize**, **describe**, and **name** science concepts, facts, and skills related to real-world situations
- **Explain**, **compare**, and **outline** appropriate science concepts, facts and skills related to real-world situations
- Use science concepts, facts and skills to **examine** and **solve** real-world situations
- **Distinguish** strengths and weaknesses of using particular science concepts, facts and skills to describe real-world situations, and categorize their different points of view, biases, values, or intents
- **Invent** or design products that involve particular science concepts, facts or skills in real-world situations
- Recommend and **prioritize** a number of different solutions to a particular real-world problem, justifying your assessment.
Instructional activities in DYS are focused on concrete Learning Objectives, expressed in terms of what we want students to know, understand, and be able to do. But what does this mean in concrete terms? How can we discern what a student knows, understands, or is able to do?

With effective planning, the teacher focuses on the assessment from the beginning, and lets students know precisely what they will be asked to do to demonstrate their level of knowledge and understanding.

While the assessments themselves should not be adjusted, the teacher should be prepared to scaffold the learning and make adjustments to the learning for various students, based on information gleaned from the ongoing formative assessments.

Rather than jump to conclusions about whether or not a student has grasped a particular body of knowledge, it is helpful first to slow down, take a deep breath, and simply express what we see. Describe in detail what you see happening. What is the student doing? What is she not doing? After noting what is happening, then consider what that means—what does your student know or not know?

Following a review of your students’ actions and what they suggest about their knowledge, then plan the actions you will take to help your students progress. How will you help? What are your next steps?

When the time comes for a summative assessment of your students, teachers should consider offering a variety of choices regarding the style in which different students communicate their learning. The intent is not to modify the criteria for the assessment; the intent is to modify the mode of assessment.

Ultimately, the beauty of planning with the assessment in mind is that when teachers plan carefully and understand what the standards are calling for, they reach the assessment part of each lesson already knowing how they will determine whether, and to what degree, students have achieved that lesson’s learning objectives.
DEFINING ASSESSMENT
Assessments include many different methods of gathering evidence to measure student progress in learning crucial material. The various assessment methods used in DYS settings may include:

PRE-ASSESSMENT
Prior to beginning a mini-unit of instruction, teachers gauge what students know, understand, and are able to do. Formal pre-assessments gather data that is specific to each student, while informal pre-assessments rest on general data for either a group of students or for individuals. All pre-assessments should target the primary learning objectives (what students should know, understand, and be able to do by the end of the mini-unit).

ASSESSMENT
Teachers observe learning by describing, collecting, recording, scoring, and interpreting information about a student’s learning. Data may be used to adjust instruction, coach students, or assist in final evaluation of student progress. Assessment data may or may not be quantitative in nature.

FORMATIVE assessment is ongoing, conducted throughout instruction to provide teachers with data regarding the degree to which a student knows, understands, or is able to do a given learning task. Quizzes, teacher observation of students, oral questioning, and other techniques yield useful information for planning, sequencing, and making adjustments to students’ learning experiences, and can be particularly useful in coaching students.

SUMMATIVE assessment takes place at the end of an instructional unit, and provides information on student performance relative to the learning objectives outlined in the mini-unit plan. Information from summative assessment is used to make a judgment or evaluation of student accomplishments in that mini-unit, and comprises a critical part of student evaluation.

PERFORMANCE-BASED ASSESSMENT
Teachers observe and assess student performance in projects, presentations, or performances using a set of established criteria. Because performance-based assessment is essentially subjective, teachers must use a scoring guide, or “rubric,” that is based on explicit criteria and clear descriptions of various levels of quality.

HOLISTIC RUBRICS combine a number of elements of performance into a short descriptive narrative for each scoring level. The emphasis is on evaluating the overall product or performance.

ANALYTIC RUBRICS separate the performance or product into its critical attributes, and each category or attribute is evaluated separately. Because it provides specific information about the various components of the performance or product, this type of rubric is useful as a coaching tool.

PORTFOLIO ASSESSMENT
Teachers evaluate a collection of each student’s work, using a pre-established set of criteria. Because performance-based assessment is essentially subjective, expectations for content and criteria for assessment must be clear to students and teachers before portfolios are created or assessed.

PORTFOLIOS include work that is representative of each student’s efforts, achievements, and progress over a period of time. Portfolios may be evaluated by scoring each piece individually, scoring of a set of pieces as a whole, or simply confirming that each required component has been included. Students’ reflection on their own work is an important component of portfolio assessment, which may include a wide range of products that demonstrate student learning, including (for example) videotapes, audio tapes, journals, completed assignments, quizzes, tests, or other sample work.
USING RUBRICS FOR AUTHENTIC ASSESSMENT

Authentic Assessment refers to methods that correspond as closely as possible to real-world experiences. These techniques were first applied in arts and apprenticeship systems, where assessment has always been based on performance. Authentic assessment takes the principles of evaluating real work into all areas of the curriculum. In using “authentic assessment,” the instructor will:

- Observe the student in the process of working on something real
- Provide feedback
- Monitor the student’s use of the feedback, and
- Adjust instruction and evaluation accordingly.

Rubrics are particularly useful in assessing student knowledge, skills, or applications on performances (such as a speech, debate, or PowerPoint presentation) or products (such as a written response, the results of a project, or a portfolio of work). In DYS settings, teachers use rubrics as scoring guides to evaluate the quality of responses constructed by students in Performance and Portfolio assessments.

Rubrics focus on responses constructed by students in their own performances and products. This emphasis is quite different from multiple-choice, matching, or similar teacher-constructed choices for responses. The advantages of using rubrics in assessment are that they allow assessment to be more objective, focus teachers to clarify their expectations in explicit terms, show students exactly what is expected and how their work will be evaluated, promote student awareness regarding the effectiveness of the instruction, and offer students and teachers benchmarks against which to measure and document progress.

Rubrics help students understand the “rules” of the classroom, providing them with insights into their own learning processes as they grow to understand why they get the scores they get. Students can become involved in both peer-and self-assessment with rubrics, as they recognize how learning is evaluated. When students become familiar with rubrics, they can also assist in the process of designing the rubrics, which empowers students and contributes to more focused and self-directed learning.

All rubrics have three essential features, described briefly below.

CRITERIA OR STANDARDS

The learning outcomes (learning objectives) that the student demonstrates through the work. What students should know, understand and be able to do, and the corresponding standards from the Massachusetts Curriculum Framework.

QUALITY DEFINITIONS

Describe the way that differences in students’ responses will be judged. For example, if a particular question requires that students provide a correct factual answer, and demonstrate the process they used, and provide a written explanation, the rubric must indicate which of these components will be considered in awarding a score. There are many options for labeling each level of quality, and the rubric must provide a clear description for each of the qualitative levels that students may achieve.

SCORING STRATEGY

May be either holistic or analytic. In a holistic strategy, the scorer takes all of the criteria into consideration but aggregates them to make a single, overall quality judgment. In an analytic strategy, the scorer gives criterion-by-criterion scores, so every criterion on a particular product or performance is given a separate score. Most commonly, the scorer gives a rating for each criterion, and then also gives a total score (usually by adding up the criterion scores).
LOOKING AT STUDENT WORK—MCAS ASSESSMENTS AND RUBRICS

In all subject areas, including science, MCAS (Massachusetts Comprehensive Assessment System) assessments rely heavily on examinations of students’ own work. For this reason, published MCAS rubrics provide a helpful guide to the process of looking at student work. The following example, released and published on the internet by the Department of Education, illuminates the process of using explicit rubrics to assess student work.

EXAMPLE

On the 2004 MCAS for Grade 10 Biology, Question 18 assessed each student’s knowledge, understanding, and ability to use Punnet squares to demonstrate Standard B 3.4:

Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, codominant, sex-linked, polygenic, incomplete dominance, multiple alleles).

Students were reminded that a Punnett square is a tool used to predict the outcome of a genetic cross, and asked to perform the following tasks:

- **a** Make a Punnett square for the cross of a father heterozygous for short fingers and a mother homozygous dominant for short fingers. Use \( B \) to indicate the allele for short fingers and \( b \) to indicate the allele for long fingers.

- **b** Identify the expected percentages of the phenotypes in the F\(_1\) generation for the cross in part a.

- **c** Make a Punnett square for the cross of a tall father who is homozygous dominant for height and a short mother who is homozygous recessive for height. Use \( T \) to indicate the allele for tall and \( t \) to indicate the allele for short.

- **d** Identify the expected percentages of the phenotypes in the F\(_1\) generation for the cross in part c.

OPEN-RESPONSE QUESTIONS

Open-response questions like this require students to generate a correct response, rather than simply recognize one. Students can use a variety of strategies and approaches, and scoring allows students to receive credit for responding correctly with different strategies and approaches. On the MCAS, written responses to open-response questions are not scored for spelling, punctuation, or grammar.

The holistic scoring guide on the facing page is taken directly from the MCAS, where it explicitly outlines the Criteria, Definitions of quality, and Scoring strategies by which the written responses to question 18 will be assessed.

Examples of real student responses to Question 18 earning 4, 3, 2, 1 or no points are provided in the pages that follow; the authentic examples of student work are accompanied by explanations of the criteria, quality definitions, and scoring strategies that were applied.
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<th>Description</th>
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<td>4</td>
<td>Response demonstrates the student’s thorough understanding of how to predict genotypes and phenotypes using a Punnett square. The response contains no errors.</td>
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<tr>
<td>3</td>
<td>Response demonstrates the student’s general understanding of how to predict genotypes and phenotypes using a Punnett square. The crosses and phenotype percentages contain minor errors OR one major error.</td>
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<tr>
<td>2</td>
<td>Response demonstrates the student’s limited understanding of how to predict genotypes and phenotypes using a Punnett square. The crosses and phenotype percentages contain minor errors OR some of the crosses and predictions contain major errors.</td>
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<tr>
<td>1</td>
<td>Response demonstrates the student’s minimal understanding of how to predict genotypes and phenotypes using a Punnett square. The crosses and phenotype percentages contain major errors.</td>
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<tr>
<td>0</td>
<td>The response is incorrect or contains correct work that is irrelevant to the skill or concept being measured.</td>
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**4 POINTS**

This response demonstrates the student’s thorough understanding of how to predict genotypes and phenotypes using a Punnett square. The response contains no errors.
3 POINTS

This response demonstrates the student’s general understanding of how to predict genotypes and phenotypes using a Punnett square. The crosses and phenotype percentages contain minor errors OR one major error.

a. $\begin{array}{ccc} & B & b \\ B & BB & Bb \\ b & BB & Bb \end{array}$

b. 100% expected to have short fingers
0% expected to have long fingers

c. $\begin{array}{ccc} & T & t \\ t & tt & Tt \\ T & Tt & Tt \end{array}$

d. 75% expected to be tall
25% expected to be short
2 POINTS

This response demonstrates the student's limited understanding of how to predict genotypes and phenotypes using a Punnett square. The crosses and phenotype percentages contain minor errors OR some of the crosses and predictions contain major errors.

A!

\[
\begin{array}{c}
B & B \\
B & BB & BB \\
b & Bb & Bb \\
\end{array}
\]

B: About 75% - 100% of the outcome is that in the F1 generation, the short fingers will be more dominant.

\[
\begin{array}{c}
T & T \\
T & TT & TT \\
T & TT & TT \\
\end{array}
\]

D: The expected percentages of the phenotypes in the F1 generation will most likely be about 100% chance that the tallness trait will be passed on.
1 POINT

This response demonstrates the student’s minimal understanding of how to predict genotypes and phenotypes using a Punnett square. The crosses and phenotype percentages contain major errors.

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B. The percentage of the phenotypes in the F1 generation is 75%.

C. 

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D. The percentage of the F1 generation is 25%.
WHERE TO FIND MORE

The MCAS release items highlighted in this manual share a common rubric that is easily adaptable for different grade levels, strands, standards, and skills. A treasure trove of released items, scoring guides, and samples of student work can all be found through the Department of Education’s website at:

http://www.doe.mass.edu/mcas/search/
Think about a particular skill, lesson, or mini-unit that you have enjoyed teaching.

What assessment methods did you use? What roles did the assessments play in your planning and instruction? What factors do you consider when selecting an assessment method?

How did you share with your students the criteria and expectations for how the work was to be evaluated?

Are particular methods of assessment better suited to different types of curriculum and instruction? Why or why not?

Quickly scan this list of different ways to gather evidence of student learning. Which methods do you use most? Why? Are there methods that you never use? Why not? What methods would you like to try for the first time?

### Process folios

### Learning logs

### True/false tests or quizzes

### Filling in the blanks

### Demonstrations

### Labeling a diagram, map, etc.

### Diaries or journals

### Competitions

### Musical, dance, or dramatic performances

### Science fairs (or similar demonstrations)

### Newspaper advertisements or other media

### Web page or other internet products

### Portfolios of work

### Observations of students

### Concept maps

### Non-linguistic (graphic) representations

### Laboratory reports and analysis

### Essays, stories, or poems

### Learning logs

### Matching

### Process folios

### Think alouds

### “Show your Work”

### Debates

### Interviews

### Short answers

### Oral questioning

### Skills tests

### Research reports

### Oral presentations
CREATING AND FINDING ASSESSMENTS AND RUBRICS ONLINE

A great many websites help teachers find and create appropriate rubrics and assessment instruments online.

At the time of publication, all of the following websites were working well, and provided teachers with no-cost assessments and tools to generate and/or customize high-quality rubrics:

- [http://pblchecklist.4teachers.org/](http://pblchecklist.4teachers.org/)
- [http://rubistar.4teachers.org](http://rubistar.4teachers.org)
- [http://www.rubrics4teachers.com](http://www.rubrics4teachers.com)
- [http://literacy.kent.edu/Midwest/assessment](http://literacy.kent.edu/Midwest/assessment)

SEARCHING THE WEB

This is another good opportunity to conduct a web-based search on Google or Dogpile, or any other large search engine, using specific terms such as, “performance assessments,” “high school,” “open-response,” “science,” “genetics,” “evolution,” “cell biology,” etc. A Boolean search for “science AND open response questions AND rubric” or “biology AND performance AND assessment” is likely to yield many valuable links and a good deal of useful information, while screening out resources that are more general.

Again, when you find pages that you consider valuable, you can use a “website copier” to save the pages, as well as all of their links, onto your computer’s hard drive. Go to [www.hittrack.com/](http://www.hittrack.com/) for a free website copier that will help you save internet resources for future use.
Acknowledgements

This science guide is the third in a series of instructional guides that focus on the content and delivery of education services in DYS facilities across the state of Massachusetts. The DYS Instructional guides are one component of the DYS LEED Education Initiative, an education reform effort led by the Commonwealth Corporation and its partnering organization, the Hampshire Educational Collaborative.

All materials in these guides are aligned with the Science and Technology/Engineering Curriculum Framework and the content standards from the Massachusetts Department of Education.

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