▪ Life Science ▪ Licensure Handbook

College of Sciences and Humanities
Ball State University

Accurate as of 12/2009

Table of Contents

Professional Education
Conceptual Framework

The mission of the professional education program at Ball State University is to prepare engaged educational experts who are sensitive and responsive to the contextual bases of teaching, learning, and development.

Context

We endorse a contextual-ecological view of education that assumes that the context of education and development is not a simple environment to which students are merely reactive but instead consists of biological, psychological, social and cultural processes that dynamically interact throughout the life course.

This means that Ball State professional education candidates will understand the multiple contexts that are operating in learning situations. They will possess a deep understanding of child and youth development and an appreciation for intellectual, social and cultural settings that may differ from their own. They will learn to design teaching/learning experiences that help learners make use of their own contextual resources to succeed.

Engagement

The theme of engagement describes an array of commitments, dispositions, and competencies that consistently lead the professional educator to energetic involvement with all aspects of potential learning situations. The pedagogy of engaged teachers reflects constructivist best practice, where meaning is constructed and learning takes place as teachers and learners participate and interact with each other and with objects and ideas.

This means that Ball State professional education candidates will learn to make use of all means of engaging learners to construct meaning and create understanding. They will study and practice instructional strategies that engage learners within the various contexts that accompany learning situations. They will apply these strategies in multiple field experience settings and evaluate the learning outcomes. And, they will engage in the broader context of relevant settings that influence educational outcomes through study of policy issues and involvement with professional societies and organizations.

Expertise

Expertise is, of course, a relative matter. We do not expect beginning teachers to be experts. Indeed, it is our view that beginning teachers require a period of induction in order to make progress towards an acceptable degree of professional competence. We approach expertise as a practice, not a state of being. In essence we expect educational professionals to know central concepts, and actively seek out additional experiences and knowledge that will provide them the opportunity to share expertise while maintaining the understanding that becoming a true expert is a lifelong endeavor.

Thus, this theme of the conceptual framework binds us to ensure that professional education candidates develop a deep and comprehensive knowledge of (a) subject matter, (b) pedagogy and pedagogical content knowledge," (c) the developmental characteristics of learners, (d) the purposes and ends of education, and further that they begin the process of developing the characteristics of expert practitioners.

To access the Ball State University Conceptual Framework for Professional Education, please go to the following URL: http://www.bsu.edu/teachers/media/pdf/cncptlfrmwrk_sept2009.pdf

Life Science

Teaching License

Ball State University

December, 2009

This handbook is designed to provide important information and guidance for students who are seeking a teaching license in ***Life Science*** in the senior high school, middle school/junior high, or both. The guide which follows should be used along with regular visits to your advisor as you progress through your program. Ultimately it is your responsibility to meet all requirements, but this handbook and your advisor can help you meet your obligations.

Advisor:

When you have questions about your program, contact your advisor.

> Get in the habit of meeting regularly,
> at least once a semester, with your advisor.

Your advisor is assigned according to the last digit of your nine digit university identification number.

- For students entering program in spring, 2009 or later:
  If your NUMBER ends in 0, 1, 2 or 3, your advisor is Dr. Tom McConnell (tjmcconnell@bsu.edu 285-8840; CL223E).

- If your NUMBER ends in 4, 5, or 6, your advisor is Dr. Melissa Mitchell (mmitchell@bsu.edu; 285-8826; CL168B).

- If your NUMBER ends in 7, 8, 9, your advisor is Dr. Shireen Desouza (jmdesouza@bsu.edu 285-8856; CL226A).

Each advisor has a mailbox in the Department of Biology office, CL121 (285-8820).
(CL = Cooper Life.) If your assigned advisor is not available, see the Biology Department Chair in CL121.

Content Contacts:

If you have questions about coursework in any of these aspects of life science, contact these content specialists:

Content Area	Contact Person	Email	Phone	Office
Botany/Gen. Bio.	Ruch, Donald	druch@bsu.edu	5-8829	CL 223D
Cell Biology	Vann, Carolyn	cvann@bsu.edu	5-5155	CL 168A
Ecology	LeBlanc, David	dleblanc@bsu.edu	5-8832	CL 223C
Genetics	Hammersmith, Robert	rhammersmith@bsu.edu	5-8837	CL 171B
Environ. Science	Gregg, Amy	algregg2@bsu.edu	5-5781	WQ 114
Human Physiology	Clark, Jeff	jclark@bsu.edu	5-8350	CL 367E
General Biology	Rogers, Bill	wrogers@bsu.edu	5-8812	CL 169D
Microbiology	Mitchell, James	jkmitchell@bsu.edu	5-8851	CL 231B
Wildlife/Zoology	Islam, Kamal	kislam@bsu.edu	5-8847	CL 231A
Entom./Zoology	Dodson, Gary	gdodson@bsu.edu	5-8859	CL 226C

Professional Associations in Life Science Education:

You should be aware of professional education associations in your field and you should join and take part in the activities of at least one state and one national association.

- National Science Teachers Association www.nsta.org
- National Association of Biology Teachers www.nabt.org
- Hoosier Association of Science Teachers, Inc. www.hasti.org
- Indiana Association of Biology Teachers www.hasti.org/groups/iabt.html

Mark your calendars for February 3-5, 2010, for the Hoosier Association of Science Teachers, Inc. (HASTI) state convention in Indianapolis.

Professional educators take part in their state and national organizations in order to learn about the latest developments in their profession and to support good science teaching.

Levels of Licensure:

You may choose to be licensed to teach life science at these levels:

Licensure Area Description	Major Code
only the senior high school level, grades 9-12	502T001
only the middle school/junior high level, grades 5-8	502T003
both middle school/junior high and senior high school levels, grades 5-12	502T002

While there are many similarities in these three options, there also are differences; so be sure to follow the plan that will entitle you to teach at your desired level or levels. If you choose to be licensed to teach life science at the high school level and general science (with a life science concentration) at the middle school/junior high level, please be aware that your program will be increased by at least one semester.

Freshman Year:

1. Let your freshman advisor know you want to pursue a professional education program in life science so you will get into the proper courses right away.

2. SCI 150, Introduction to Science Teaching, is the required first course in all science teaching programs, including life science. **While SCI 150 is offered in both the fall and spring semester; it is suggested that you take it in your first semester you are enrolled at Ball State.**

3. If you plan to teach at the senior high level only or at both the senior high and middle school/junior high levels, then in your freshman year take these courses in these semesters:

Fall	Spring
BIO 112 Principles of Biology	BIO 210 Principles of Biology 3
CHEM 111 General Chemistry 1	CHEM 112 General Chemistry 2

4. If you plan to teach only at the middle school/junior high level, then in your freshman year take these courses in these semesters:

Fall	Spring
ASTRO 120 Star Systems	BIO 112 Principles of Biology
ASTRO 121 Honors Lab	CHEM 112 General Chemistry 2
CHEM 111 General Chemistry 1	

5. The rest of your freshman year schedule will be made up of Core Studies courses.

Life Science Course Requirements:

The following courses for fifty-seven (57) hours of credit are required for life science licensure to **teach at the senior high level**.

BIO	111	4	Principles of Biology 1
	112	4	Principles of Biology 2
	210	3	Intro Botany
	213	4	Microbiology
	214	4	Genetics
	215	4	Cell Biology
	216	3	Ecology
	217	2	Methods in Ecology
	440	3	Evolution
PHYSL	205	3	Fund. Human Physiology
CHEM	111	4	General Chemistry 1
	112	4	General Chemistry 2
	231	4	Organic Chemistry 1
PHYCS	110	4	General Physics 1
	112	4	General Physics 2

Statistics (Choose 1 of these 2 courses)

MATHS	181	3	Elem. Prob/Stats
BIO	448	3	Biometry
TOTAL		**57**	

If you want to add a middle school license to the high school license, then you must also take these additional thirteen (13) hours.

GEOG	230	3	Elem. Meteorology
ASTRO	120	3	Stars and Stellar Systems
	121	1	Astronomy Lab
GEOL	102	3	Earth, Life, Time
NREM	101	3	Environ. & Society
TOTAL		**13**	

Note that if you wish to add the middle school/junior high license to the senior high license or vice versa, then you will need to add a semester to your program.

The following courses for fifty-eight (58) hours of credit are required for life science licensure to **teach science at the middle school/junior high level** with a life science concentration.

BIO	111	4	Principles of Biology 1
	112	4	Principles of Biology 2
CHEM	111	4	General Chemistry 1
	112	4	General Chemistry 2
PHYCS	110	4	General Physics 1
	112	4	General Physics 2
ASTRO	120	3	Stars and Stellar Sys.
	121	1	Astronomy Lab
GEOL	102	3	Earth, Life, Time
GEOG	230	3	Elem. Meteorology
NREM	101	3	Environ. & Society

Statistics (Choose 1 of these 2 courses)

MATHS	181	3	Elem. Prob/Stats
BIO	448	3	Biometry

Life Science Concentration (22 hrs)

BIO	210	3	Intro Botany
	214	4	Genetics
	216	3	Ecology
	217	2	Methods in Ecology
	440	3	Evolution
PHYSL	205	3	Fund. Human Physiology

TOTAL 58

If you want to add a high school license to the middle school/junior high school license, then you must also take these additional twelve (12) hours which will add a semester to your program.

BIO	213	4	Microbiology
BIO	215	4	Cell Biology
CHEM	231	4	Organic Chemistry 1

TOTAL 12

When to Take Courses:

The program leading to life science licensure is very full and complete, so it is important that you take courses in a certain sequence when the courses are available. Don't procrastinate.

On the next four pages you will find a suggested four year plan of when to take courses, if you are seeking:

- high school life science licensure and you enter Ball State University in fall of an even-numbered year (go to Schedule A).
- high school life science licensure and you enter Ball State University in fall of an odd-numbered year (go to Schedule B).
- middle school/junior high science licensure with a life science concentration and you enter Ball State University in fall of an even-numbered year (go to Schedule C).
- middle school/junior high science licensure with a life science concentration and you enter Ball State University in fall of an odd-numbered year (go to Schedule D).

Schedule A

Four-Year Plan for High School Life Science Education Program

(For Students Who Matriculate as Freshmen in Fall of Even Years)

Freshman Fall (Even year)				**Code**	**Freshman Spring**				**Code**
BIO	112	Princ. Biol. 2	4	B	BIO	210	Intro Botany	3	B
CHEM	111	Gen. Chem. 1	4	B	CHEM	112	Gen Chem 1	4	B
SCI	150	Basic Concpt	3	B	Core Studies			11	
Core Studies			6						
Total			**17**		**Total**			**18**	

Sophomore Fall (Odd year)					**Sophomore Spring**				
BIO	111	Princ. Biol. 1	4	B	BIO	214	Genetics	4	B
CHEM	231	Organ Chem	4	B	PHYCS	110	Gen Physics 1	4	B
EDMUL	205	Multi Educ	3	B	SCI	295	Int. Tch. Sci	3	S
EDPSY	251	Hu Grow Dev	3	B	Core Studies			3	
Core Studies			3						
Total			**17**		**Total**			**17**	

Junior Fall (Even year)					**Junior Spring**				
PHYCS	112	Gen Physics 2	4	B	BIO	215	Cell Biology	4	B
PHYSL	205	Ess Hum Physl	3	F	BIO	213	Microbiology	4	B
BIO	216	Ecology	3	B	EDPSY	390	Educ Psych	3	B
BIO	217	Ecology Methods	2	F	Core Studies			6	
EDFON	420	Fnds of Educ	3	B					
Total			**15**		**Total**			**17**	

Senior Fall (Odd year)					**Senior Spring**				
BIO	440	Evolution	3	FO	EDSEC	460	St Tch	6	B
EDSEC	380	Prin Sec Sch	3	B	EDSEC	465	St Tch	6	B
EDJHM	385	Prin Mid Sch	3	B					
SCI	396	Sci Mth Mtrl	3	F					
Statistics required course			3	B					
Core Studies			3						
Total			**18**		**Total**			**12**	

TOTAL PROGRAM: 131

Course Codes

B: Course offered Fall and Spring semesters, every year
F: Course offered only Fall semester, every year
S: Course offered only Spring semester, every year
FO:Course offered only Fall semester of odd-numbered years
FE: Course offered only Fall semester of even-numbered years
SO:Course offered only Spring semester of odd-numbered years
SE: Course offered only Spring semester of even-numbered years

Schedule B

Four-Year Plan for High School Life Science Education Program

(For Students Who Matriculate as Freshmen in Fall of Odd Years)

Freshman Fall (Odd year)				**Code**
BIO	112	Prin. Biol. 2	4	B
CHEM	111	Gen. Chem. 1	4	B
SCI	150	Basic Concpt	3	B
Core Studies			6	
Total			**17**	

Freshmen Spring				**Code**
BIO	210	Intro Botany	3	B
CHEM	112	Gen Chem 1	4	B
Core Studies			11	
Total			**18**	

Sophomore Fall (Even year)				
BIO	111	Princ. Biol. 1	4	B
CHEM	231	Organ Chem	4	B
EDMUL	205	Multi Educ	3	B
EDPSY	251	Hu Grow Dev	3	B
Core Studies			3	
Total			**17**	

Sophomore Spring				
BIO	216	Ecology	3	B
	214	Genetics	4	B
BIO	213	Microbiology	4	B
SCI	295	Int. Tch. Sci.	3	S
Core Studies			3	
Total			**17**	

Junior Fall (Odd year)				
PHYCS	110	Gen Physics 1	4	B
BIO	217	Ecol Meth	2	F
BIO	440	Evolution	3	FO
EDFON	420	Fnds of Educ	3	B
Core Studies			3	
Total			**15**	

Junior Spring				
PHYCS	112	Gen Physics 2	4	B
BIO	215	Cell Biology	4	B
EDPSY	390	Educ Psychol	3	B
Core Studies			6	
Total			**17**	

Senior Fall (Even year)				
PHYSL	205	Ess Hum Physl	3	F
EDSEC	380	Prin Sec Sch	3	B
EDJHM	385	Prin Mid Sch	3	B
SCI	396	Sci Mth Mtrl	3	F
Statistics required course			3	B
Core Studies			3	
Total			**18**	

Senior Spring				
EDSEC	460	St Tch	6	B
EDSEC	465	St Tch	6	B
Total			**12**	

TOTAL PROGRAM: 131

Course Codes

B: Course offered Fall and Spring semesters, every year
F: Course offered only Fall semester, every year
S: Course offered only Spring semester, every year
FO: Course offered only Fall semester of odd-numbered years
FE: Course offered only Fall semester of even-numbered years
SO: Course offered only Spring semester of odd-numbered years
SE: Course offered only Spring semester of even-numbered years

Schedule C

Four-Year Plan for Middle School Science (Life Science Concentration) Education Program

(For Students Who Matriculate as Freshmen in Fall of Even Years)

Freshman Fall (Even year)				**Code**	**Freshmen Spring**				**Code**
ASTRO	120	Star Systems	3	F	BIO	112	Princ Biol 2	4	B
ASTRO	121	Honors Lab	1	F	CHEM	112	Gen Chem 1	4	B
CHEM	111	Gen. Chem. 1	4	B	Core Studies			9	
SCI	150	Basic Concpt	3	B					
Core Studies			6						
Total			**17**		**Total**			**17**	
Sophomore Fall (Odd year)					**Sophomore Spring**				
BIO	111	Princ. Biol. 1	4	B	BIO	210	Intro Botany	3	B
PHYCS	110	Gen Physics 1	4	B	PHYCS	112	Gen Physics 2	4	B
EDMUL	205	Multi Educ	3	B	Statistics required course			3	B
EDPSY	251	Hu Grow Dev	3	B	SCI	295	Int. Tch. Sci	3	S
Core Studies			3		Core Studies			5	
Total			**17**		**Total**			**18**	
Junior Fall (Even year)					**Junior Spring**				
GEOG	230	Elem Meteor	3	B	BIO	214	Genetics	4	B
PHYSL	205	Ess Hum Physl	3	F	EDPSY	390	Educ Psychol	3	B
BIO	216	Ecology	3	B	Core Studies			9	
BIO	217	Ecology Methods	2	F					
EDFON	420	Fnds of Educ	3	B					
Core Studies			3						
Total			**17**		**Total**			**16**	
Senior Fall (Odd year)					**Senior Spring**				
BIO	440	Evolution	3	FO	EDSEC	460	St Tch	6	B
EDSEC	380	Prin Sec Sch	3	B	EDSEC	465	St Tch	6	B
EDJHM	385	Prin Mid Sch	3	B					
SCI	396	Sci Mth Mtrl	3	F					
GEOL	102	Earth Time	3	B					
NREM	101	Env. & Soc.	3	B					
Total			**18**		**Total**			**12**	

TOTAL PROGRAM: 132

Course Codes

B: Course offered Fall and Spring semesters, every year
B: Course offered only Fall semester, every year
S: Course offered only Spring semester, every year
FO:Course offered only Fall semester of odd-numbered years
FE: Course offered only Fall semester of even-numbered years
SO:Course offered only Spring semester of odd-numbered years
SE: Course offered only Spring semester of even-numbered years

Schedule D

Four-Year Plan for Middle School Science (Life Science Concentration) Education Program

(For Students Who Matriculate as Freshmen in Fall of Odd Years)

Freshman Fall (Odd year)				**Code**	**Freshmen Spring**				**Code**
ASTRO	120	Star Systems	3	F	BIO	112	Princ Biol 2	4	B
ASTRO	121	Honors Lab	1	F	CHEM	112	Gen Chem 1	4	B
CHEM	111	Gen. Chem. 1	4	B	Core Studies			9	
SCI	150	Basic Concpt	3	B					
Core Studies			6						
Total			**17**		**Total**			**17**	

Sophomore Fall (Even year)					**Sophomore Spring**				
BIO	111	Princ. Biol. 1	4	B	BIO	210	Intro Botany	3	B
BIO	216	Ecology	3	B	GEOG	230	Elem Meteor	3	B
BIO	217	Ecology Methods	2	F	NREM	101	Env. & Soc.	3	B
EDMUL	205	Multi Educ	3	B	SCI	295	Int Tch Sci	3	S
EDPSY	251	Hu Grow Dev	3	B	Core Studies			6	
Core Studies			3						
Total			**18**		**Total**			**18**	

Junior Fall (Odd year)					**Junior Spring**				
PHYCS	110	Gen Physics 1	4	B	PHYCS	112	Gen Physics 2	4	B
BIO	440	Evolution	3	FO	Statistics required course			3	B
BIO	214	Genetics	4	B	EDPSY	390	Educ Psychol	3	B
EDFON	420	Fnds of Educ	3	B	Core Studies			6	
Core studies			3						
Total			**17**		**Total**			**16**	

Senior Fall (Even year)					**Senior Spring**				
PHYSL	205	Ess Hum Physl	3	F	EDSEC	460	St Tch	6	B
GEOL	102	Earth Time	3	B	EDSEC	465	St Tch	6	B
EDSEC	380	Prin Sec Sch	3	B					
EDJHM	385	Prin Mid Sch	3	B					
SCI	396	Sci Mth Mtrl	3	F					
Core Studies			2						
Total			**17**		**Total**			**12**	

TOTAL PROGRAM: 132

Course Codes

B: Course offered Fall and Spring semesters, every year
F: Course offered only Fall semester, every year
S: Course offered only Spring semester, every year
FO: Course offered only Fall semester of odd-numbered years
FE: Course offered only Fall semester of even-numbered years
SO: Course offered only Spring semester of odd-numbered years
SE: Course offered only Spring semester of even-numbered years

Standards:

In order to become a life science teacher you must meet requirements based on standards established at the national level by the Interstate New Teacher Assessment and Support Consortium (INTASC) and the International Society for Technology in Education (ISTE). As a life science teacher you must also meet standards established at the state level by the Indiana Professional Standards Board (IPSB). The courses you take along with certain required experiences and tests are designed to allow you to achieve these standards.

> You will learn more about these standards and how to meet them in SCI 150 during your freshman year.

The INTASC, ISTE and IPSB science standards are found in the addenda at the end of this handbook.

Life Science Teachers *Impact* the future

Decision Points:

As you move through your Ball State life science program you will have to successfully pass four "decision points" that check your progress. The following tables list what you have to do in order to pass each decision point.

Artifacts in your electronic portfolio will come in different forms. They may be a report you write to describe research you did as part of a science course, a set of lesson plans you create in a science teaching methods course, a video of you teaching science to high school students, and so forth. Artifacts will be added to your portfolio so you can show others that you can do the things that teachers are supposed to be able to do. Each artifact should include the student's work, the instructor's assessment, and a reflective statement written by you which describes (a) what was learned from the assignment and (b) how the artifact demonstrates mastery of INTASC Principles (See Addenda).

The following chart shows how many and what kinds of artifacts must be included in your portfolio at each decision point.

Digital Portfolio Information by Decision Points

Decision Point	Reflective Statement Requirements	Teacher's College Artifact & Rationale Requirements	Life Science Licensure Area Artifact & Rational Requirements
Decision Point 1	A reflective statement for each of the 10 INTASC Principles clearly labeled DP 1.	One artifact showing competency in one INTASC principle with accompanying rationale clearly labeled DP1. (Total = minimum of 1 artifact).	• Sci 150 Classroom Management plan for INTASC Principle #5
Decision Point 2	Revised set of ten reflective statements that meet DP2 expectations.	Three artifacts showing competency in three INTASC principles with accompanying rationales clearly labeled DP2. (Total = minimum of 3 artifacts).	• Sci 295 Biographical PowerPoint Presentation for INTASC Principle #6 • Sci 295 5-E Instructional Model lesson plan for INTASC Principle #7 • EdPsy 250-251artifact for INTASC Principle #2 • EdMul 205 artifact for INTASC Principle #3
Decision Point 3	Revised set of ten reflective statements that meet DP3 expectations.	One artifact for each seven of the ten INTASC principles with accompanying rationales clearly labeled DP3 (Total = minimum of 7 artifacts).	• Sci 396 Science Safety Plan for INTASC Principle #10
Decision Point 4	Ten new reflective statements (one for each of the 10 INTASC principles) clearly labeled DP4	Two new artifacts with accompanying rationales clearly labeled DP4 for each of the ten INTASC principles.	

Relevant Digital Portfolio Timeline for Decision Point 3

Digital Portfolios will be scored at DP1 by your SCI 150 instructor.

Digital Portfolios will be scored at DP2 by your Science Advisor by appointment.

Digital Portfolios will be scored at DP3 by your Science Advisor according to the following timeline:

Tuesday, Week 12	Portfolios must be submitted by 11:59 p.m.
Tuesday, Week 14	Assessments must be recorded in rGrade by 5:00 p.m.
Tuesday, Week 14	Assessments become visible to teach candidates after 6:00 p.m.
Last Day of Classes	Revised portfolios must be resubmitted by teacher candidates
Grade Submission Deadline	RE-evaluation by evaluators who deemed a portfolio unsatisfactory is due in rGrade by 8:00 a.m.
Grade Submission Date	Assessments become visible to teacher candidates after 9:00 a.m.

Decision Point 1

Normally students prepare for Decision Point 1 during the freshman year. After passing this point you are known as a *Professional Education Aspirant*.

	Tasks Required to Pass Decision Point 1	Comment
1.	Complete at least four science content courses required for life science licensure with a grade of at least C-.	Grades will appear on the DAPR.
2.	Complete SCI 150 with grade of a C or better.	Grades will appear on the DAPR.
3.	Acquire knowledge of INTASC and IPSB standards.	Part of SCI 150.
4.	Initiate your electronic portfolio.	Part of SCI 150.
5.	Include in your electronic portfolio **at least** one performance-based artifact from SCI 150.	The portfolio will be assessed by your SCI 150 instructor for completeness, organization, and professional appearance.

Decision Point 2

Normally students pass Decision Point 2 during the sophomore year. After passing this point you:

- are admitted to the Teacher Education Program,
- are known as a *Professional Education Pre-Candidate*, and
- may register for 300 and 400 level professional education courses.

	Tasks Required to Pass Decision Point 2	Comment
1.	Pass the PPST, the Pre-Professional Skills Test of reading, writing, and mathematics.	Register for the PPST prior to the start of your sophomore year.
2.	Complete BIO 111, 112, and 210 and CHEM 111 and 112 with a grade of C- or better in each course.	Grades will appear on the DAPR.
3.	Have a GPA of at least 2.3 in all required courses for life science licensure taken to date.	Grades will appear on the DAPR.
4.	Have an overall GPA of at least 2.5 in at least 45 semester hours.	Your GPA will appear on the DAPR.
5.	Be approved for admission to the Teaching Curriculum.	See www.bsu.edu/teachers/current
6.	Complete 100 and 200 level Professional Education courses with a grade of C or better.	Grades will appear on the DAPR.
7.	Complete COMM 210 with a grade of C or better.	Grades will appear on the DAPR.
8.	Meet ISTE standards at the general preparation level.	These standards will be met as part of the science content courses you take.
9.	Include in your electronic portfolio a total of **at least** five performance-based artifacts including those required by SCI 150, SCI 295, EDMUL 205, and EDPSYCH 250.	The portfolio will be assessed by your science advisor for completeness, organization, and professional appearance. It must be deemed satisfactory before you can pass Decision Point 2.

Decision Point 3

You must pass this decision point before you are allowed to student teach. After passing this point you are known as a *Professional Education Candidate*.

	Tasks Required to Pass Decision Point 3	Comment
1.	Be within 9 hrs. of completing all required science content courses with a grade of C- or better.	Grades will appear on the DAPR.
2.	Have a GPA of at least 2.5 in all required science courses for life science licensure.	Grades will appear on the DAPR.
3.	Have a C or better in all 300 and 400 level Professional Education courses.	Grades will appear on the DAPR.
4.	Have a GPA of at least 2.5 in all required Professional Education courses.	Grades will appear on the DAPR.
5.	Have a GPA of at least 2.5 in at least 93 semester hours.	Grades will appear on the DAPR.
6.	Receive an overall score at/or above the 50^{th} percentile on the ETS Biology exit examination for university graduates.	Register for this test at the start of your junior year in the Biology department office in CL 121. You may take this exam more than once.
7.	Pass the Ball State University writing competency test.	Register for this test at the start of your junior year in the BSU Assessment Office WQ 200.
8	Meet ISTE standards at the professional preparation level.	These standards will be met as part of the science content courses you take.
9.	Include in your electronic portfolio a total of **at least** seven performance-based artifacts from standards-related content or pedagogy courses including the one required from SCI 396. Artifacts represent at least seven of the ten INTASC Principles are required.	The portfolio will be assessed by your science advisor for completeness, organization, and professional appearance. It must be deemed satisfactory before you can pass Decision Point 3.
10.	Receive a score of basic or above on the Disposition Rubric.	This rubric will be scored by your science advisor at the same time your portfolio is accessed.

* It is highly recommended that you take the Praxis II Biology Exam prior to student teaching so that you have time to retake it if necessary.

Decision Point 4

Passage of Decision Point 4 is normally synonymous with passing student teaching and with graduation. After passing this point you are known as a *Professional Educator*.

	Tasks Required to Pass Decision Point 4	Comment
1.	Have a GPA of at least 2.5 in all required science courses for life science licensure.	Grades will appear on the DAPR.
2.	Have a GPA of at least 2.5 in all required Professional Education courses.	Grades will appear on the DAPR.
3.	Have a GPA of at least 2.5 in all courses.	Grades will appear on the DAPR.
4.	Pass Student Teaching.	Grade will appear on the DAPR.
5.	Pass the PRAXIS II Biology exam.	Sign up for this exam in TC903. Preparation is strongly recommended; practice booklets are available.
6.	Meet ISTE standards at the intern level.	These standards will be met as part of the science content courses you take.
7.	Complete the Student Teaching Portfolio.	Part of Student Teaching.
8.	Meet all other graduation requirements.	See www.bsu.edu/web/catalog/index.html

Student Teaching:

Students should apply for student teaching in October of the year prior to that in which they expect to student teach. Applications are available at the Office of Educational Field Experiences in TC 915.

Graduation:

Remember that you are a life science teaching major in the College of Sciences and Humanities, so at commencement go to the designated location for CSH graduates.

Addenda

INTASC Principles
IPSB Science Standards
ISTE Technology Standards

INTASC Standards for New Teachers

Interstate New Teachers Assessment and Support Consortium

http://www.ccsso.org/intascst.html

Principle #1: The teacher understands the central concepts, tools of inquiry, and structures of the discipline(s) he or she teaches and can create learning experiences that make these aspects of subject matter meaningful for students.

Knowledge

- The teacher understands major concepts, assumptions, debates, processes of inquiry, and ways of knowing that are central to the discipline(s) s/he teaches.
- The teacher understands how students' conceptual frameworks and their misconceptions for an area of knowledge can influence their learning.
- The teacher can relate his/her disciplinary knowledge to other subject areas.

Dispositions

- The teacher realizes that subject matter knowledge is not a fixed body of facts but is complex and ever-evolving. S/he seeks to keep abreast of new ideas and understandings in the field.
- The teacher appreciates multiple perspectives and conveys to learners how knowledge is developed from the vantage point of the knower.
- The teacher has enthusiasm for the discipline(s) s/he teaches and sees connections to everyday life.
- The teacher is committed to continuous learning and engages in professional discourse about subject matter knowledge and children's learning of the discipline.

Performances

- The teacher effectively uses multiple representations and explanations of disciplinary concepts that capture key ideas and link them to students' prior understandings.
- The teacher can represent and use differing viewpoints, theories, "ways of knowing" and methods of inquiry in his/her teaching of subject matter concepts.
- The teacher can evaluate teaching resources and curriculum materials for their comprehensiveness, accuracy, and usefulness for representing particular ideas and concepts.
- The teacher engages students in generating knowledge and testing hypotheses according to the methods of inquiry and standards of evidence used in the discipline.
- The teacher develops and uses curricula that encourage students to see, question, and interpret ideas from diverse perspectives.
- The teacher can create interdisciplinary learning experiences that allow students to integrate knowledge, skills, and methods of inquiry from several subject areas.

Principle #2: The teacher understands how children learn and develop, and can provide learning opportunities that support their intellectual, social and personal development.

Knowledge

- The teacher understands how learning occurs--how students construct knowledge, acquire skills, and develop habits of mind--and knows how to use instructional strategies that promote student learning.
- The teacher understands that students' physical, social, emotional, moral and cognitive development influence learning and knows how to address these factors when making instructional decisions.
- The teacher is aware of expected developmental progressions and ranges of individual variation within each domain (physical, social, emotional, moral and cognitive), can identify levels of readiness in learning, and understands how development in any one domain may affect performance in others.

Dispositions

- The teacher appreciates individual variation within each area of development, shows respect for the diverse talents of all learners, and is committed to help them develop self-confidence and competence.
- The teacher is disposed to use students' strengths as a basis for growth, and their errors as an opportunity for learning.

Performances

- The teacher assesses individual and group performance in order to design instruction that meets learners' current needs in each domain (cognitive, social, emotional, moral, and physical) and that leads to the next level of development.
- The teacher stimulates student reflection on prior knowledge and links new ideas to already familiar ideas, making connections to students' experiences, providing opportunities for active engagement, manipulation, and testing of ideas and materials, and encouraging students to assume responsibility for shaping their learning tasks.
- The teacher accesses students' thinking and experiences as a basis for instructional activities by, for example, encouraging discussion, listening and responding to group interaction, and eliciting samples of student thinking orally and in writing.

Principle #3: The teacher understands how students differ in their approaches to learning and creates instructional opportunities that are adapted to diverse learners.

Knowledge

- The teacher understands and can identify differences in approaches to learning and performance, including different learning styles, multiple intelligences, and performance modes, and can design instruction that helps use students' strengths as the basis for growth.
- The teacher knows about areas of exceptionality in learning--including learning disabilities, visual and perceptual difficulties, and special physical or mental challenges.
- The teacher knows about the process of second language acquisition and about strategies to support the learning of students whose first language is not English.
- The teacher understands how students' learning is influenced by individual experiences, talents, and prior learning, as well as language, culture, family and community values.

- The teacher has a well-grounded framework for understanding cultural and community diversity and knows how to learn about and incorporate students' experiences, cultures, and community resources into instruction.

Dispositions

- The teacher believes that all children can learn at high levels and persists in helping all children achieve success.
- The teacher appreciates and values human diversity, shows respect for students' varied talents and perspectives, and is committed to the pursuit of "individually configured excellence."
- The teacher respects students as individuals with differing personal and family backgrounds and various skills, talents, and interests.
- The teacher is sensitive to community and cultural norms.
- The teacher makes students feel valued for their potential as people, and helps them learn to value each other.

Performances

- The teacher identifies and designs instruction appropriate to students' stages of development, learning styles, strengths, and needs.
- The teacher uses teaching approaches that are sensitive to the multiple experiences of learners and that address different learning and performance modes.
- The teacher makes appropriate provisions (in terms of time and circumstances for work, tasks assigned, communication and response modes) for individual students who have particular learning differences or needs.
- The teacher can identify when and how to access appropriate services or resources to meet exceptional learning needs.
- The teacher seeks to understand students' families, cultures, and communities, and uses this information as a basis for connecting instruction to students' experiences (e.g. drawing explicit connections between subject matter and community matters, making assignments that can be related to students' experiences and cultures).
- The teacher brings multiple perspectives to the discussion of subject matter, including attention to students' personal, family, and community experiences and cultural norms.
- The teacher creates a learning community in which individual differences are respected.

Principle #4: The teacher understands and uses a variety of instructional strategies to encourage students' development of critical thinking, problem solving, and performance skills.

Knowledge

- The teacher understands the cognitive processes associated with various kinds of learning (e.g. critical and creative thinking, problem structuring and problem solving, invention, memorization and recall) and how these processes can be stimulated.
- The teacher understands principles and techniques, along with advantages and limitations, associated with various instructional strategies (e.g. cooperative learning, direct instruction, discovery learning, whole group discussion, independent study, interdisciplinary instruction).
- The teacher knows how to enhance learning through the use of a wide variety of materials as well as human and technological resources (e.g. computers, audio-visual technologies, videotapes and discs, local experts, primary documents and artifacts, texts, reference books, literature, and other print resources).

Dispositions

- The teacher values the development of students' critical thinking, independent problem solving, and performance capabilities.

- The teacher values flexibility and reciprocity in the teaching process as necessary for adapting instruction to student responses, ideas, and needs.

Performances

- The teacher carefully evaluates how to achieve learning goals, choosing alternative teaching strategies and materials to achieve different instructional purposes and to meet student needs (e.g. developmental stages, prior knowledge, learning styles, and interests).

- The teacher uses multiple teaching and learning strategies to engage students in active learning opportunities that promote the development of critical thinking, problem solving, and performance capabilities and that help student assume responsibility for identifying and using learning resources.

- The teacher constantly monitors and adjusts strategies in response to learner feedback.

- The teacher varies his or her role in the instructional process (e.g. instructor, facilitator, coach, audience) in relation to the content and purposes of instruction and the needs of students.

- The teacher develops a variety of clear, accurate presentations and representations of concepts, using alternative explanations to assist students' understanding and presenting diverse perspectives to encourage critical thinking.

Principle #5: The teacher uses an understanding of individual and group motivation and behavior to create a learning environment that encourages positive social interaction, active engagement in learning, and self-motivation.

Knowledge

- The teacher can use knowledge about human motivation and behavior drawn from the foundational sciences of psychology, anthropology, and sociology to develop strategies for organizing and supporting individual and group work.

- The teacher understands how social groups function and influence people, and how people influence groups.

- The teacher knows how to help people work productively and cooperatively with each other in complex social settings.

- The teacher understands the principles of effective classroom management and can use a range of strategies to promote positive relationships, cooperation, and purposeful learning in the classroom.

- The teacher recognizes factors and situations that are likely to promote or diminish intrinsic motivation, and knows how to help students become self-motivated.

Dispositions

- The teacher takes responsibility for establishing a positive climate in the classroom and participates in maintaining such a climate in the school as whole.

- The teacher understands how participation supports commitment, and is committed to the expression and use of democratic values in the classroom.

- The teacher values the role of students in promoting each other's learning and recognizes the importance of peer relationships in establishing a climate of learning.
- The teacher recognizes the value of intrinsic motivation to students' life-long growth and learning.
- The teacher is committed to the continuous development of individual students' abilities and considers how different motivational strategies are likely to encourage this development for each student.

Performances

- The teacher creates a smoothly functioning learning community in which students assume responsibility for themselves and one another, participate in decisionmaking, work collaboratively and independently, and engage in purposeful learning activities.
- The teacher engages students in individual and cooperative learning activities that help them develop the motivation to achieve, by, for example, relating lessons to students' personal interests, allowing students to have choices in their learning, and leading students to ask questions and pursue problems that are meaningful to them.
- The teacher organizes, allocates, and manages the resources of time, space, activities, and attention to provide active and equitable engagement of students in productive tasks.
- The teacher maximizes the amount of class time spent in learning by creating expectations and processes for communication and behavior along with a physical setting conducive to classroom goals.
- The teacher helps the group to develop shared values and expectations for student interactions, academic discussions, and individual and group responsibility that create a positive classroom climate of openness, mutual respect, support, and inquiry.
- The teacher analyzes the classroom environment and makes decisions and adjustments to enhance social relationships, student motivation and engagement, and productive work.
- The teacher organizes, prepares students for, and monitors independent and group work that allows for full and varied participation of all individuals.

Principle #6: The teacher uses knowledge of effective verbal, nonverbal, and media communication techniques to foster active inquiry, collaboration, and supportive interaction in the classroom.

Knowledge

- The teacher understands communication theory, language development, and the role of language in learning.
- The teacher understands how cultural and gender differences can affect communication in the classroom.
- The teacher recognizes the importance of nonverbal as well as verbal communication.
- The teacher knows about and can use effective verbal, nonverbal, and media communication techniques.

Dispositions

- The teacher recognizes the power of language for fostering self-expression, identity development, and learning.
- The teacher values many ways in which people seek to communicate and encourages many modes of communication in the classroom.
- The teacher is a thoughtful and responsive listener.

- The teacher appreciates the cultural dimensions of communication, responds appropriately, and seeks to foster culturally sensitive communication by and among all students in the class.

Performances

- The teacher models effective communication strategies in conveying ideas and information and in asking questions (e.g. monitoring the effects of messages, restating ideas and drawing connections, using visual, aural, and kinesthetic cues, being sensitive to nonverbal cues given and received).

- The teacher supports and expands learner expression in speaking, writing, and other media.

- The teacher knows how to ask questions and stimulate discussion in different ways for particular purposes, for example, probing for learner understanding, helping students articulate their ideas and thinking processes, promoting risk-taking and problem-solving, facilitating factual recall, encouraging convergent and divergent thinking, stimulating curiosity, helping students to question.

- The teacher communicates in ways that demonstrate a sensitivity to cultural and gender differences (e.g. appropriate use of eye contact, interpretation of body language and verbal statements, acknowledgment of and responsiveness to different modes of communication and participation).

- The teacher knows how to use a variety of media communication tools, including audio-visual aids and computers, to enrich learning opportunities.

Principle #7: The teacher plans instruction based upon knowledge of subject matter, students, the community, and curriculum goals.

Knowledge

- The teacher understands learning theory, subject matter, curriculum development, and student development and knows how to use this knowledge in planning instruction to meet curriculum goals.

- The teacher knows how to take contextual considerations (instructional materials, individual student interests, needs, and aptitudes, and community resources) into account in planning instruction that creates an effective bridge between curriculum goals and students' experiences.

- The teacher knows when and how to adjust plans based on student responses and other contingencies.

Dispositions

- The teacher values both long term and short term planning.

- The teacher believes that plans must always be open to adjustment and revision based on student needs and changing circumstances.

- The teacher values planning as a collegial activity.

Performances

- As an individual and a member of a team, the teacher selects and creates learning experiences that are appropriate for curriculum goals, relevant to learners, and based upon principles of effective instruction (e.g. that activate students' prior knowledge, anticipate preconceptions, encourage exploration and problem-solving, and build new skills on those previously acquired).

- The teacher plans for learning opportunities that recognize and address variation in learning styles and performance modes.

- The teacher creates lessons and activities that operate at multiple levels to meet the developmental and individual needs of diverse learners and help each progress.

- The teacher creates short-range and long-term plans that are linked to student needs and performance, and adapts the plans to ensure and capitalize on student progress and motivation.

- The teacher responds to unanticipated sources of input, evaluates plans in relation to short- and long-range goals, and systematically adjusts plans to meet student needs and enhance learning.

Principle #8: The teacher understands and uses formal and informal assessment strategies to evaluate and ensure the continuous intellectual, social and physical development of the learner.

Knowledge

- The teacher understands the characteristics, uses, advantages, and limitations of different types of assessments (e.g. criterion-referenced and norm-referenced instruments, traditional standardized and performance-based tests, observation systems, and assessments of student work) for evaluating how students learn, what they know and are able to do, and what kinds of experiences will support their further growth and development.

- The teacher knows how to select, construct, and use assessment strategies and instruments appropriate to the learning outcomes being evaluated and to other diagnostic purposes.

- The teacher understands measurement theory and assessment-related issues, such as validity, reliability, bias, and scoring concerns.

Dispositions

- The teacher values ongoing assessment as essential to the instructional process and recognizes that many different assessment strategies, accurately and systematically used, are necessary for monitoring and promoting student learning.

- The teacher is committed to using assessment to identify student strengths and promote student growth rather than to deny students access to learning opportunities.

Performances

- The teacher appropriately uses a variety of formal and informal assessment techniques (e.g. observation, portfolios of student work, teacher-made tests, performance tasks, projects, student self-assessments, peer assessment, and standardized tests) to enhance her or his knowledge of learners, evaluate students' progress and performances, and modify teaching and learning strategies.

- The teacher solicits and uses information about students' experiences, learning behavior, needs, and progress from parents, other colleagues, and the students themselves.

- The teacher uses assessment strategies to involve learners in self-assessment activities, to help them become aware of their strengths and needs, and to encourage them to set personal goals for learning.

- The teacher evaluates the effect of class activities on both individuals and the class as a whole, collecting information through observation of classroom interactions, questioning, and analysis of student work.

- The teacher monitors his or her own teaching strategies and behavior in relation to student success, modifying plans and instructional approaches accordingly.

- The teacher maintains useful records of student work and performance and can communicate student progress knowledgeably and responsibly, based on appropriate indicators, to students, parents, and other colleagues.

Principle #9: The teacher is a reflective practitioner who continually evaluates the effects of his/her choices and actions on others (students, parents, and other professionals in the learning community) and who actively seeks out opportunities to grow professionally.

Knowledge

- The teacher understands methods of inquiry that provide him/her with a variety of self- assessment and problem-solving strategies for reflecting on his/her practice, its influences on students' growth and learning, and the complex interactions between them.

- The teacher is aware of major areas of research on teaching and of resources available for professional learning (e.g. professional literature, colleagues, professional associations, professional development activities).

Dispositions

- The teacher values critical thinking and self-directed learning as habits of mind.

- The teacher is committed to reflection, assessment, and learning as an ongoing process.

- The teacher is willing to give and receive help.

- The teacher is committed to seeking out, developing, and continually refining practices that address the individual needs of students.

- The teacher recognizes his/her professional responsibility for engaging in and supporting appropriate professional practices for self and colleagues.

Performances

- The teacher uses classroom observation, information about students, and research as sources for evaluating the outcomes of teaching and learning and as a basis for experimenting with, reflecting on, and revising practice.

- The teacher seeks out professional literature, colleagues, and other resources to support his/her own development as a learner and a teacher.

- The teacher draws upon professional colleagues within the school and other professional arenas as supports for reflection, problem-solving and new ideas, actively sharing experiences and seeking and giving feedback.

Principle #10: The teacher fosters relationships with school colleagues, parents, and agencies in the larger community to support students' learning and well-being.

Knowledge

- The teacher understands schools as organizations within the larger community context and understands the operations of the relevant aspects of the system(s) within which s/he works.

- The teacher understands how factors in the students' environment outside of school (e.g. family circumstances, community environments, health and economic conditions) may influence students' life and learning.

- The teacher understands and implements laws related to students' rights and teacher responsibilities (e.g. for equal education, appropriate education for handicapped students, confidentiality, privacy, appropriate treatment of students, reporting in situations related to possible child abuse).

Dispositions

- The teacher values and appreciates the importance of all aspects of a child's experience.
- The teacher is concerned about all aspects of a child's well-being (cognitive, emotional, social, and physical), and is alert to signs of difficulties.
- The teacher is willing to consult with other adults regarding the education and well-being of his/her students.
- The teacher respects the privacy of students and confidentiality of information.
- The teacher is willing to work with other professionals to improve the overall learning environment for students.

Performances

- The teacher participates in collegial activities designed to make the entire school a productive learning environment.
- The teacher makes links with the learners' other environments on behalf of students, by consulting with parents, counselors, teachers of other classes and activities within the schools, and professionals in other community agencies.
- The teacher can identify and use community resources to foster student learning.
- The teacher establishes respectful and productive relationships with parents and guardians from diverse home and community situations, and seeks to develop cooperative partnerships in support of student learning and well being.
- The teacher talks with and listens to the student, is sensitive and responsive to clues of distress, investigates situations, and seeks outside help as needed and appropriate to remedy problems.
- The teacher acts as an advocate for students.

Standards for Teachers of Science

Indiana Professional Standards Board (IPSB)

http://www.IN.gov/psb/future/science.htm

Standard #1: The teacher of science understands the central concepts, tools of inquiry, and the history and nature of science in order to create learning experiences that make these aspects of science meaningful for the student.

Performances

1. The teacher of science conveys his/her enthusiasm for learning science to all.
2. The teacher of science teaches the central concepts and processes of science in personally and socially relevant ways.
3. The teacher of science concentrates on teaching a few fundamental science concepts. (Refer to Appendix G.)
4. The teacher of science provides opportunities for students to explore the continuum of interactions in the natural world.
5. The teacher of science selects developmentally appropriate science concepts and processes for their instruction. (Refer to Appendix G.)
6. The teacher of science helps students build scientific knowledge and develop scientific habits of mind at the same time.
7. The teacher of science provides students with many and varied opportunities for asking questions, collecting data, using evidence to develop explanations, and communicating their ideas to others.
8. The teacher of science provides opportunities for student investigations that take place over extended periods of time.
9. The teacher of science models science habits of the mind in the classroom. (Refer to Appendix F.)
10. The teacher of science provides students with many opportunities to view science in its cultural and historical context by using examples from history and including scientists of both genders and all social and cultural groups.
11. The teacher of science uses science teaching materials that portray the dynamic history and nature of science.
12. The teacher of science provides students with experiences for seeing science as a process for extending understanding, not as unalterable truth.
13. The teacher of science uses technology appropriately and supports the use of technology among students.

Knowledge

Central Concepts:

1. The teacher of science possesses a knowledge and understanding of science appropriate to the developmental level and subject area needs of students. (Refer to Appendix A.)
2. The teacher of science understands the unifying concepts and processes of science. (Refer to Appendix B.)
3. The teacher of science understands the fundamental concepts and major principles of Physical, Life, and Earth and Space science and the interconnections between these disciplines. (Refer to Appendix C.)
4. The teacher of science understands the abilities of technological design and the relationship between science and technology. (Refer to Appendix D.)

5. The teacher of science understands the interrelationship of personal and social perspectives in science. (Refer to Appendix E.)

6. The teacher of science understands the habits of mind particular to science. (Refer to Appendix F.)

7. The teacher of science knows which science concepts and processes are appropriate at the developmental level at which they teach. (Refer to Appendix G.)

Tools of Inquiry:

8. The teacher of science understands how to identify questions and concepts that guide scientific investigations.

9. The teacher of science understands how to design and conduct scientific investigations.

10. The teacher of science understands how to use technology and mathematics to improve investigations and communications.

11. The teacher of science knows how to interpret the results of an investigation and make sense of findings using logic and evidence.

12. The teacher of science understands how to recognize and analyze alternative explanations and models.

13. The teacher of science understands how to communicate and defend a scientific argument.

14. The teacher of science knows when, where, and how to access needed information.

History of Science:

15. The teacher of science knows that the history of science can help students build an understanding of the scientific enterprise.

16. The teacher of science recognizes that some episodes in the history of science have led to major changes in our view of the world.

17. The teacher of science knows that science often changes by small modifications in existing knowledge, but that new scientific ideas that lead to major changes in scientific thinking can be slow to be accepted.

18. The teacher of science knows that science has been practiced by different individuals in different cultures throughout history.

19. The teacher of science knows that individual scientists and teams of scientists have made significant contributions to our current understanding of scientific principles.

Nature of Science:

20. The teacher of science understands that science is a human endeavor, involving both genders and all social, cultural, and ethnic groups, in teams and alone, that relies on human qualities such as reasoning, insight, energy, skill, and creativity as well as scientific habits of mind such as intellectual honesty, skepticism, and openness to new ideas.

21. The teacher of science understands that scientists are influenced by societal, cultural, and personal beliefs.

22. The teacher of science understands that the scientific community plays an important role, through public reporting and peer review, in deciding what counts as significant questions and reasonable evidence.

23. The teacher of science knows that science is a way of knowing that involves devising the best possible explanations for phenomena in the natural world.

24. The teacher of science knows that scientific explanations are formulated and tested using observations, experiments, and/or theoretical models.

25. The teacher of science understands that scientists often differ with one another about the interpretation of the evidence or theory being considered, yet also understands that although scientists may disagree about explanations or evidence, they agree that critical evaluation of the results of scientific investigations, models, and explanations is an essential part of science.

26. The teacher of science knows that scientific explanations must be consistent with evidence, make accurate predictions, be logical, be open to criticism, and be public.

27. The teacher of science knows that scientific knowledge is tentative and subject to change as new evidence or new ways of thinking become available.

Dispositions

1. The teacher of science is enthusiastic about learning and teaching science.

2. The teacher of science appreciates that some science concepts and processes are inappropriate at certain developmental levels. (Refer to Appendix G.)

3. The teacher of science values the learning of science concepts and processes in personally and socially relevant ways.

4. The teacher of science values the integration of all aspects of science content.

5. The teacher of science commits to focusing on fundamental science concepts. (Refer to Appendix G.)

6. The teacher of science appreciates the need to understand and develop scientific concepts through inquiry.

7. The teacher of science values science habits of the mind to make sense of ideas and events in the classroom and in his/her daily life. (Refer to Appendix E.)

8. The teacher of science is a lifelong learner who is curious and open to new ideas and concepts.

9. The teacher of science recognizes and values the contributions of scientists of both genders and all social and cultural groups in the development of scientific ideas.

10. The teacher of science appreciates that science takes place within a cultural and social context that influences the questions asked, the data collected, and the explanations developed.

11. The teacher of science recognizes that there are no absolute authorities in science, but that science is open to debate and discussion.

12. The teacher of science recognizes creativity and invention as important qualities for doing science.

13. The teacher of science appreciates the aesthetic value of science.

14. The teacher of science values technology.

Standard #2: The teacher of science understands how students learn science and provides science learning opportunities that support their intellectual, social, and personal development.

Performances

1. The teacher of science engages students in actually doing science.
2. The teacher of science assesses individual differences in order to design instruction that meets learners' diverse intellectual, social, and personal development.
3. The teacher of science stimulates student reflection on prior knowledge and links new ideas to already familiar ideas, thereby making connections to students' experience, providing opportunities for active engagement, manipulation, and testing of ideas and materials, and encouraging students to assume responsibility for shaping their learning tasks.
4. The teacher of science assesses students' science conceptions through discussions, interviews, surveys, concept maps, etc., and uses findings as a basis for selecting instructional strategies.

Knowledge

1. The teacher of science understands commonly held conceptions of students and how these may affect their learning.
2. The teacher of science understands how learning occurs -- how students construct scientific knowledge, acquire inquiry skills, and develop scientific habits of mind -- and knows how to use instructional strategies that promote student learning of science.
3. The teacher of science understands that students' intellectual, social, and personal development influences the learning of science and knows how to address these factors when making instructional decisions.
4. The teacher of science is aware of expected developmental progressions and ranges of individual variation within the students' intellectual, social, and personal development.
5. The teacher of science understands that students learn best when they experience things that are tangible and directly stimulate their senses --- visual, auditory, tactile, or kinesthetic.
6. The teacher of science understands that the direct sensory experiencing of phenomena are most easily understood when they occur in a way that is relevant to the learner.
7. The teacher of science understands that student difficulties in grasping abstractions are often masked by their ability to recite technical terms that they do not understand.

Dispositions

1. The teacher of science enthusiastically embraces his/her role as an advocate of each student learning science.
2. The teacher of science appreciates each student as a unique individual who has equal value regardless of social, political, economic, ethnic, gender, religious, or intellectual differences.
3. The teacher of science believes that each student can learn and perform at high levels.
4. The teacher of science is interested in and sensitive to the students' science conceptions.

Standard #3: The teacher of science understands how students differ in their approaches to learning science and creates instructional opportunities that are adapted to diverse learners.

Performances

1. The teacher of science makes students feel valued for their potential as people and helps them learn to value each other.

2. The teacher of science defers judgment about students and their motivations until a comprehensive analysis of the student is possible.

3. The teacher of science identifies and designs instruction appropriate to the students' stages of development, learning styles, strengths, and needs.

4. The teacher of science uses teaching approaches that are sensitive to the multiple experiences of learners and that address different learning and performance modes.

5. The teacher of science makes appropriate provisions for individual students who have particular learning differences or needs.

6. The teacher of science can identify when and how to access appropriate services or resources to meet the exceptional learning needs of students.

7. The teacher of science uses understandings of students' families, cultures, and communities as a basis for connecting instruction to the students' experiences.

8. The teacher of science models tolerance and respect for individual differences.

Knowledge

1. The teacher of science understands and can identify differences in approaches to learning and performance, including different learning styles, multiple intelligences, and performance modes, and can adapt instruction to the needs of diverse learners.

2. The teacher of science knows about areas of exceptionality in learning, including learning disabilities, visual and perceptual difficulties, and special physical or mental challenges.

3. The teacher of science knows about the process of second language acquisition and about strategies to support the learning of students whose first language is not English.

4. The teacher of science understands how students' learning is influenced by individual experiences, talents, language, culture, family, and community values.

5. The teacher of science has a well-grounded framework for understanding cultural and community diversity and knows how to incorporate students' experiences, cultures, and community resources into instruction.

6. The teacher of science understands a wide range of cultural and social differences through direct involvement and the study of human interactions.

7. The teacher of science understands that behavior is most often a reflection of many factors.

Dispositions

1. The teacher of science believes that all children can learn science.

2. The teacher of science respects the varied talents and perspectives of students.

3. The teacher of science recognizes that the importance of diversity among students is as important to the learning community as biodiversity is to the natural community.

4. The teacher of science is sensitive to the entire community and its individuals.

Standard #4: The teacher of science understands and uses a variety of instructional strategies to encourage students' development of conceptual understanding, inquiry skills, and scientific habits of mind.

Performances

1. The teacher of science focuses inquiry primarily on real phenomena, in classrooms, outdoors, or in laboratory settings, where students are given investigations or guided toward fashioning investigations that are demanding but within their capabilities.

2. The teacher of science and the students often collaborate in the pursuit of ideas.

3. The teacher of science models and encourages the skills of scientific inquiry, as well as the curiosity, openness to new ideas, and skepticism that characterize science.

4. The teacher of science critically selects instructional strategies in order to achieve specific science learning goals and to meet individual student needs.

5. The teacher of science uses instructional strategies that engage students in scientific inquiry and that develop scientific habits of mind.

6. The teacher of science constantly monitors and adjusts teaching strategies in response to learner feedback.

7. The teacher of science uses a variety of representations and activities to help students make sense of science concepts.

Knowledge

1. The teacher of science understands that inquiry into authentic questions generated from student experiences is the central strategy for teaching science.

2. The teacher of science understands the processes associated with scientific inquiry and how these processes can be developed.

3. The teacher of science understands that science is often a collaborative endeavor and that all science depends on the ultimate sharing and debating of ideas.

4. The teacher of science understands various teaching models and instructional strategies for helping students develop conceptual understandings.

5. The teacher of science recognizes the need for ongoing assessment of his/her teaching and of student learning in determining appropriate instructional strategies.

6. The teacher of science possesses a repertoire of activities and representations and understands their usefulness and limitations in helping students build conceptual understandings.

7. The teacher of science knows how to enhance learning through the use of a wide variety of materials as well as human and technological resources.

Dispositions

1. The teacher of science believes in creating a learning community and working together with students as active learners.

2. The teacher of science believes that science instruction should develop students' conceptual understandings, inquiry skills, and science habits of the mind. (Refer to Appendix F)

3. The teacher of science recognizes that students need many different opportunities to make sense of science concepts and to develop inquiry skills and science habits of the mind.

Standard #5: The teacher of science uses an understanding of individual and group motivation and behavior to create science learning environments that encourage positive social interaction and active engagement in learning.

Performances

1. The teacher of science creates a smoothly functioning learning community in which students assume responsibility for themselves and one another, participate in decision making, work collaboratively and independently, and engage in purposeful learning activities.

2. The teacher of science engages students in individual and cooperative learning activities that help them develop motivation to achieve by, for example, relating lessons to students' personal interests, allowing students to have choices in their learning, and leading students to ask questions and pursue problems that are meaningful to them.

3. The teacher of science organizes, allocates, and manages resources of time, space, activities, and attention to provide active and equitable engagement of students in productive tasks.

4. The teacher of science maximizes the amount of class time spent in learning by creating expectations and processes for communication and behavior along with a physical setting suitable to classroom goals.

5. The teacher of science helps the group to develop shared values and expectations for student interactions, academic discussions, and individual and group responsibility that create a positive classroom climate of openness, sensitivity, mutual respect, support, and inquiry.

Knowledge

1. The teacher of science understands the dynamics of group behavior and strategies that create a science learning community in the classroom.

2. The teacher of science knows how to encourage both individual and group involvement in scientific inquiry.

3. The teacher of science knows how to guide students to establish group and individual goals in their learning of science.

4. The teacher of science understands the principles of classroom management and knows how to ensure that all students are purposefully involved in doing and learning science.

5. The teacher of science knows how to select appropriate science activities to engage all students in learning the central concepts and processes of science.

Dispositions

1. The teacher of science acknowledges that the group learning process has to be nurtured by creating cohesive science learning groups in which every member is valued.

2. The teacher of science believes that by asking questions students will be motivated to find the answers to their questions.

3. The teacher of science believes that science is often a collaborative endeavor and that all science depends on the ultimate sharing and debating of ideas (scientific discourse).

4. The teacher of science values effective classroom management as a means of maintaining student focus.

5. The teacher of science believes in the importance of selecting science activities and teaching methods that respond to student diversity.

6. The teacher of science realizes that student involvement in the inquiry process will be strengthened if students have interest and involvement in the planning.

Standard #6: The teacher of science understands and uses a variety of communication techniques to foster equity, inquiry, collaboration, and supportive interaction in the classroom.

Performances

1. The teacher of science monitors his/her interactions with students to ensure equitable participation of all students in all facets of science instruction.

2. The teacher of science uses questioning and response strategies (e.g., productive questions, wait time) that encourage thinking and doing as opposed to merely recalling and reciting.

3. The teacher of science uses writing, drawing, and speaking in science to help students clarify their ideas, develop new ideas, and demonstrate understanding.

4. The teacher of science models effective scientific discourse, helps strengthen developmentally appropriate scientific discourse among students, and orchestrates discourse among students about scientific ideas.

5. The teacher of science uses a variety of resources and media communication tools, including the Internet, microcomputer-based laboratories, and audio-visual aides, to enrich science learning opportunities.

Knowledge

1. The teacher of science understands how cultural and gender differences in communication can lead to differences in science learning.

2. The teacher of science knows questioning and response strategies (e.g., productive questions, wait time) that lead to thinking and doing rather than recalling and reciting.

3. The teacher of science understands that writing, drawing, and speaking can help students clarify their understandings, develop new understandings, and demonstrate their understanding.

4. The teacher of science understands how scientific discourse differs from everyday language and recognizes that students may not see the difference.

Dispositions

1. The teacher of science recognizes the power of language for fostering equitable science learning opportunities and desires to develop equitable classroom communication.

2. The teacher of science values and encourages many modes of communication in the science class (e.g., discussion, telecommunications, writing and drawing, graphing, making models).

3. The teacher of science values listening to students to make sense of their conceptual understandings.

4. The teacher of science recognizes and appreciates the difficulty students have in distinguishing scientific discourse from everyday language.

Standard #7: The teacher of science plans meaningful science instruction based upon knowledge of science, students, the community, science curricula, and curriculum goals.

Performances

1. The teacher of science selects and creates learning experiences that are based upon principles of effective instruction and that are appropriate for curriculum goals and for students.
2. The teacher of science plans learning opportunities that recognize and address variation in learning styles and performance modes.
3. The teacher of science creates lessons and activities that will be useful at multiple levels to address the developmental and individual needs of diverse learners and adjust plans as needed to meet student needs and enhance learning.
4. The teacher of science plans science instruction that incorporates community issues, needs, and resources.

Knowledge

1. The teacher of science understands science concepts, learning theory, the nature of science, science curricula, curriculum development, and student development and knows how to use this knowledge in planning instruction to meet curriculum goals.
2. The teacher of science is aware of the variety of curricula and resource materials and knows how to choose and use those materials with the greatest educational value.
3. The teacher of science is aware of the developmental level, aptitudes, interests, and needs of students and knows how to use this information to create effective learning experiences.
4. The teacher of science is aware of community issues, needs, and resources and knows how to use this knowledge to develop educational experiences relevant to his/her students.
5. The teacher of science is flexible and knows how to adjust instructional plans to address the changing needs of students.

Dispositions

1. The teacher of science values both long-term and short-term planning.
2. The teacher of science believes that plans must always be open to revision to assure that they meet the needs of students and the community.
3. The teacher of science believes that plans for learning experiences should be developmentally appropriate.
4. The teacher of science values planning as a collegial activity.

Standard #8: The teacher of science understands and uses a variety of authentic and equitable assessment strategies to evaluate and ensure the continuous intellectual, social, and personal development of the learner.

Performances

1. The teacher of science uses science assessments that focus on all aspects of science achievement (e.g., ability to inquire, scientific understanding of the natural world, and understanding of the nature and utility of science).
2. The teacher of science monitors and modifies his/her own teaching strategies in relation to student success.
3. The teacher of science designs assessments that focus on students' knowledge, understandings, and reasoning.

4. The teacher of science uses both formal and informal assessment methods.

5. The teacher of science helps students develop skills in reflection by building a learning environment where students review their own and each other's work.

6. The teacher of science provides opportunities for students to have input into the assessment process.

7. The teacher of science designs assessments that are developmentally appropriate, contextually familiar to students, and free from bias.

8. The teacher of science maintains evidence of student performance that communicates student progress knowledgeably and responsibly to students, parents, and colleagues.

9. The teacher of science provides all students an opportunity to learn by differentiating the instruction to meet individual needs.

Knowledge

1. The teacher of science understands the various methods for assessment of science learning (e.g., performance tasks, interviews, student presentations, computer simulations, writing science, observations, questions, and standard tests) and how assessment is linked to curriculum and instruction.

2. The teacher of science knows how to select, construct, and use a variety of assessment strategies and instruments appropriate to learning outcomes.

3. The teacher of science understands that the interactions of teachers and students concerning evaluation criteria help students understand the expectations for their work and give them experience in applying standards of scientific practice to their own and others' scientific endeavors. (p. 42 - *National Science Standards*)

4. The teacher of science understands measurement theory and assessment-related issues (e.g., validity, reliability, bias, and rubric development).

5. The teacher of science understands that students must be given an opportunity to learn science prior to assessing their learning.

Dispositions

1. The teacher of science values the students' learning experiences.

2. The teacher of science believes that students are serious learners who can develop the responsibility for their own learning.

3. The teacher of science believes that ongoing assessment is essential to the instructional process.

4. The teacher of science recognizes that many different assessment strategies are necessary and essential for monitoring and promoting student learning.

5. The teacher of science realizes that science assessments should equitably measure what a student of science has an opportunity to learn, to do, and to know.

6. The teacher of science values the time and intellectual commitment necessary to conduct authentic assessment.

Standard #9: The teacher of science is a reflective practitioner who continually evaluates the effects of his/her choices and actions on others, and who actively pursues opportunities to grow professionally.

Performances

1. The teacher of science uses classroom observation, information about students, and research as sources for evaluating the outcomes of teaching and learning and as a basis for experimenting with, reflecting on, and revising practice.

2. The teacher of science seeks out professional literature, colleagues, and other resources to support his/her own development as a learner and a teacher.

3. The teacher of science draws upon colleagues within the school and other professional arenas to support his/her professional development.

4. The teacher of science pursues professional development opportunities to access new scientific knowledge and instructional methods and to incorporate them into relevant learning situations for students.

Knowledge

1. The teacher of science understands methods of inquiry that provide him/her with a variety of self-assessment and problem-solving strategies for reflecting on his/her practice, its influences on students' growth and learning, and the complex interactions between them.

2. The teacher of science is aware of major areas of research on science teaching and of resources available for professional learning (e.g., professional literature, colleagues, professional associations, professional development activities).

3. The teacher of science is aware that the body of knowledge in all fields of science is continually expanding.

Dispositions

1. The teacher of science values critical thinking and self-directed learning as habits of mind.

2. The teacher of science commits to reflection, assessment, and learning as an ongoing process.

3. The teacher of science values working with colleagues to continually evaluate effectiveness and relevance in his/her teaching.

4. The teacher of science commits to seeking out, developing, and continually refining practices that address the individual needs of students.

5. The teacher of science recognizes his/her professional responsibility for engaging in and supporting appropriate professional practices for self and colleagues.

6. The teacher of science recognizes the importance of keeping abreast of new discoveries, research, and the constantly increasing knowledge in all fields of science.

Standard #10: In order to support student learning and well-being, the teacher of science fosters relationships with students and their families, colleagues, and concerned others.

Performances

1. The teacher of science involves the students, their families, and concerned others in establishing appropriate and relevant science learning goals.

2. The teacher of science utilizes a variety of community resources to promote students' awareness of how the knowledge of science can be applied to their own community.

3. The teacher of science collaborates with other professionals within and outside of their school community in order to expand science knowledge, learn more effective methods of teaching science, and gain insights into the needs of individual students.

4. The teacher of science talks with and listens to students and is sensitive and responsive to clues of distress and reports findings to appropriate people.

5. The teacher of science supports individuals, families, and communities by honoring their traditions, customs, and beliefs.

Knowledge

1. The teacher of science knows that in order to understand students, his/her relationship with students must extend beyond the classroom.

2. The teacher of science understands that establishing communication with students and their families will foster a strong unified support system for the science student.

3. The teacher of science knows that science teaching is connected and related to the resources and concerns of the community.

4. The teacher of science understands how factors in the students' environment outside of school may influence their lives and learning.

5. The teacher of science understands that collaboration with students, colleagues, and community influences learning.

6. The teacher of science is aware of student rights and the teacher's responsibility in upholding these rights.

Dispositions

1. The teacher of science is aware that open communication with science students and their families promotes mutual respect.

2. The teacher of science values all segments of the community (e.g., social and governmental agencies, community businesses, and community advocacy groups) to enhance the science learning environment.

3. The teacher of science values fellow professionals who are interested in improving the science learning environment.

4. The teacher of science values student input into the improvement of the science learning environment.

5. The teacher of science is an advocate for the student and is willing to support the right of each student to be safe, to be treated equitably, and to have an opportunity to learn.

6. The teacher of science respects the privacy of students and the confidentiality of information.

Appendix A (From: NRC, National Science Education Standards)
Developmental Level Content Requirements

All teachers of science must have a strong, broad base of scientific knowledge which is extensive enough for them to:

- Understand the nature of scientific inquiry, its central role in science, and how to use the skills and processes of scientific inquiry.
- Understand the fundamental facts and concepts in major science disciplines.
- Be able to make conceptual connections within and across science disciplines, as well as to mathematics, technology, and other school subjects.
- Use scientific understanding and ability when dealing with personal and societal issues.

This broad base is outlined in more detail in Appendices B, C, D, E, and F. While this breadth of knowledge is essential for all teachers, the depth of science content required varies according to the developmental level of the students.

Early childhood and middle childhood teachers are generalists who teach most, if not all, school subjects. A primary task for these teachers is to lay the experiential, conceptual, and attitudinal foundation for future learning in science by guiding students through a range of inquiry activities. To achieve this, early childhood and middle childhood teachers of science need to have the opportunity to develop a broad knowledge of science content in addition to <u>some in-depth experiences in at least one science subject</u>. Such in-depth experiences will allow teachers to develop an understanding of inquiry and the structure and production of science knowledge. That knowledge prepares teachers to guide student inquiries, appraise current student understanding, and further students' understanding of scientific ideas. Although thorough science knowledge in many areas would enhance the work of an early childhood and middle childhood teacher, it is more realistic to expect a generalist's knowledge.

Science curricula are organized in many different ways in the middle grades. Science experiences go into greater depth, are more quantitative, require more sophisticated reasoning skills, and use more sophisticated apparatus and technology. These requirements of the science courses change the character of the conceptual background required of early adolescent teachers of science. While maintaining a breadth of science knowledge, they need to develop greater depth of understanding than their colleagues teaching in earlier grades. <u>An intensive, thorough study of at least one scientific discipline</u> will help them meet the demands of their teaching and gain appreciation for how scientific knowledge is produced and how disciplines are structured.

For teachers of adolescent and young adult students, effective teachers of science possess broad knowledge of all disciplines and a deep understanding of all disciplines and a deep understanding of the scientific disciplines they teach. This implies being familiar enough with a <u>science discipline to take part in research activities within that discipline</u>.

Additionally, teachers of science at all levels must possess an understanding of what content is appropriate for students to master at certain levels, and what content is appropriate to be introduced at certain levels. Refer to Appendix G for more information.

Appendix B (From: NRC, National Science Education Standards)

The Unifying Concepts and Processes of Science

SYSTEMS, ORDER, AND ORGANIZATION

The natural and designed world is complex; it is too large and complicated to investigate and comprehend all at once. Scientists and students learn to define small portions for the convenience of investigation. The units of investigation can be referred to as "systems." A system is an organized group of related objects or components that form a whole. Systems can consist, for example, of organisms, machines, fundamental particles, galaxies, ideas, numbers, transportation, and education. Systems have boundaries, components, resources flow (input and output), and feedback.

The goal of this standard is to think and analyze in terms of systems. Thinking and analyzing in terms of systems will help students keep track of mass, energy, objects, organisms, and events referred to in the other content standards. The idea of simple systems encompasses subsystems as well as identifying the structure and function of systems, feedback and equilibrium, and the distinction between open and closed systems.

Science assumes that the behavior of the universe is not capricious, that nature is the same everywhere, and that it is understandable and predictable. Students can develop an understanding of regularities in systems, and by extension, the universe; they then can develop understanding of basic laws, theories, and models that explain the world.

Newton's laws of force and motion, Kepler's laws of planetary motion, conservation laws, Darwin's laws of natural selection, and chaos theory all exemplify the idea of order and regularity. An assumption of order establishes the basis for cause-effect relationships and predictability.

Prediction is the use of knowledge to identify and explain observations, or changes, in advance. The use of mathematics, especially probability, allows for greater or lesser certainty of predictions.

Order--the behavior of units of matter, objects, organisms, or events in the universe--can be described statistically. Probability is the relative certainty (or uncertainty) that individuals can assign to selected events happening (or not happening) in a specified space or time. In science, reduction of uncertainty occurs through such processes as the development of knowledge about factors influencing objects, organisms, systems, or events; better and more observations; and better explanatory models.

Types and levels of organization provide useful ways of thinking about the world. Types of organization include the periodic table of elements and the classification of organisms. Physical systems can be described at different levels of organization--such as fundamental particles, atoms, and molecules. Living systems also have different levels of organization--for example, cells, tissues, organs, organisms, population, and communities. The complexity and number of fundamental units change in extended hierarchies of organization. Within these systems, interactions between components occur. Further, systems at different levels of organization can manifest different properties and functions.

EVIDENCE, MODELS, AND EXPLANATION

Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems.

Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. Models help scientists and engineers understand how things work. Models take many forms, including physical objects, plans, mental constructs, mathematical equations, and computer simulations.

Scientific explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements. Different terms, such as "hypothesis," "model," "law," "principle," "theory," and "paradigm" are used to describe various types of scientific explanations. As students develop and as they understand more science concepts and processes, their explanations should become more sophisticated. That is, their scientific explanations should more frequently include a rich scientific knowledge base, evidence of logic, higher levels of analysis, greater tolerance of criticism and uncertainty, and a clearer demonstration of the relationship between logic, evidence, and current knowledge.

CONSTANCY, CHANGE, AND MEASUREMENT

Although most things are in the process of becoming different--changing--some properties of objects and processes are characterized by constancy, including the speed of light, the charge of an electron, and the total mass plus energy in the universe. Changes might occur, for example, in properties of materials, position of objects, motion, and form and function of systems. Interactions within and among systems result in change. Changes vary in rate, scale, and pattern, including trends and cycles.

Energy can be transferred and matter can be changed. Nevertheless, when measured, the sum of energy and matter in systems, and by extension in the universe, remains the same.

Changes in systems can be quantified. Evidence for interactions and subsequent change and the formulation of scientific explanations are often clarified through quantitative distinctions--measurement. Mathematics is essential for accurately measuring change.

Different systems of measurement are used for different purposes. Scientists usually use the metric system. An important part of measurement is knowing when to use which system. For example, a meteorologist might use degrees Fahrenheit when reporting the weather to the public, but in writing scientific reports, the meteorologist would use degrees Celsius.

Scale includes understanding that the different characteristics, properties, or relationships within a system might change as its dimensions are increased or decreased.

Rate involves comparing one measured quantity with another measured quantity, for example, 60 meters per second. Rate is also a measure of change for a part relative to the whole, for example, change in birth rate as part of population growth.

EVOLUTION AND EQUILIBRIUM

Evolution is a series of changes, some gradual and some sporadic, that account for the present form and function of objects, organisms, and natural and designed systems. The general idea of evolution is that the present arises from materials and forms of the past. Although evolution is most commonly associated with the biological theory explaining the process of descent with modification of organisms from common ancestors, evolution also describes changes in the universe.

Equilibrium is a physical state in which forces and changes occur in opposite and off-setting directions: for example, opposite forces are of the same magnitude, or off-setting changes occur at equal rates. Steady state, balance, and homeostasis also describe equilibrium states. Interacting units of matter tend toward equilibrium states in which the energy is distributed as randomly and uniformly as possible.

FORM AND FUNCTION

Form and function are complementary aspects of objects, organisms, and systems in the natural and designed world. The form or shape of an object or system is frequently related to use, operation, or function. Function frequently relies on form. The understanding of form and function applies to different levels of organization. Students should be able to explain function by referring to form, and to explain form by referring to function.

Appendix C (From: NRC, National Science Education Standards)
The Fundamental Concepts and Major Principles of Physical, Life, and Earth and Space Science

1) Physical Science

STRUCTURE OF ATOMS

- Matter is made of minute particles called atoms, and atoms are composed of even smaller components. These components have measurable properties, such as mass and electrical charge. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric force between the nucleus and electrons holds the atom together.
- The atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that differ in the number of neutrons, these atoms are called different isotopes of the element.
- The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars.
- Radioactive isotopes are unstable and undergo spontaneous nuclear reactions, emitting particles and/or wavelike radiation. The decay of any one nucleus cannot be predicted, but a large group of identical nuclei decay at a predictable rate. This predictability can be used to estimate the age of materials that contain radioactive isotopes.

STRUCTURE AND PROPERTIES OF MATTER

- Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. These outer electrons govern the chemical properties of the element.
- An element is composed of a single type of atom. When elements are listed in order according to the number of protons (called the atomic number), repeating patterns of physical and chemical properties identify families of elements with similar properties. This "Periodic Table" is a consequence of the repeating pattern of outermost electrons and their permitted energies.
- Bonds between atoms are created when electrons are paired up by being transferred or shared. A substance composed of a single kind of atom is called an element. The atoms may be bonded together into molecules or crystalline solids. A compound is formed when two or more kinds of atoms bind together chemically.
- The physical properties of compounds reflect the nature of the interactions among its molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them.
- Solids, liquids, and gases differ in the distances and angles between molecules or atoms and therefore the energy that binds them together. In solids the structure is nearly rigid; in liquids molecules or atoms move around each other but do not move apart; and in gases molecules or atoms move almost independently of each other and are mostly far apart.
- Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life.

CHEMICAL REACTIONS

- Chemical reactions occur all around us, for example in health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies.
- Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog.
- A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. In other reactions, chemical bonds are broken by

heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, the burning and processing of fossil fuels, the formation of polymers, and explosions.

- Chemical reactions can take place in time periods ranging from the few femtoseconds (10^{-15}seconds) required for an atom to move a fraction of a chemical bond distance to geologic time (scales of billions of years). Reaction rates depend on how often the reacting atoms and molecules encounter one another, on the temperature, and on the properties--including shape--of the reacting species.

- Catalysts, such as metal surfaces, accelerate chemical reactions. Chemical reactions in living systems are catalyzed by protein molecules called enzymes.

MOTIONS AND FORCES

- Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship $F = ma$, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.

- Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.

- Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.

- The electric force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. The strength of the force is proportional to the charges, and, as with gravitation, inversely proportional to the square of the distance between them.

- Between any two charged particles, electric force is vastly greater than the gravitational force. Most observable forces such as those exerted by a coiled spring or friction may be traced to electric forces acting between atoms and molecules.

- Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. These effects help students to understand electric motors and generators.

CONSERVATION OF ENERGY AND THE INCREASE IN DISORDER

- The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered.

- All energy can be considered to be either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; or energy contained by a field, such as electromagnetic waves.

- Heat consists of random motion and the vibrations of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion.

- Everything tends to become less organized and less orderly over time. Thus, in all energy transfers, the overall effect is that the energy is spread out uniformly. Examples are the transfer of energy from hotter to cooler objects by conduction, radiation, or convection and the warming of our surroundings when we burn fuels.

INTERACTIONS OF ENERGY AND MATTER

- Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.

- Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.

- Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance.

- In some materials, such as metals, electrons flow easily, whereas in insulating materials such as glass they can hardly flow at all. Semiconducting materials have intermediate behavior. At low temperatures some materials become superconductors and offer no resistance to the flow of electrons.

2) Life Science

THE CELL

- Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and the storage of genetic material.

- Most cell functions involve chemical reactions. Food molecules taken into cells react to provide the chemical constituents needed to synthesize other molecules. Both breakdown and synthesis are made possible by a large set of protein catalysts, called enzymes. The breakdown of some of the food molecules enables the cell to store energy in specific chemicals that are used to carry out the many functions of the cell.

- Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires.

- Cell functions are regulated. Regulation occurs both through changes in the activity of the functions performed by proteins and through the selective expression of individual genes. This regulation allows cells to respond to their environment and to control and coordinate cell growth and division.

- Plant cells contain chloroplasts, the site of photosynthesis. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital connection between the sun and the energy needs of living systems.

- Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. In the development of these multicellular organisms, the progeny from a single cell form an embryo in which the cells multiply and differentiate to form the many specialized cells, tissues, and organs that comprise the final organism. This differentiation is regulated through the expression of different genes.

THE MOLECULAR BASIS OF HEREDITY

- In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "letters") and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.

- Most of the cells in a human contain two copies of each of 22 different chromosomes. In addition, there is a pair of chromosomes that determines sex: a female contains two X chromosomes and a male contains one X and one Y chromosome. Transmission of genetic information to offspring occurs through egg and sperm cells that contain only one representative from each chromosome pair. An egg and a sperm unite to form a new individual. The fact that the human body is formed from cells that contain two copies of each chromosome--and therefore two copies of each gene--explains many features of human heredity, such as how variations that are hidden in one generation can be expressed in the next.

- Changes in DNA (mutations) occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism's offspring.

BIOLOGICAL EVOLUTION

- Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.

- The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms.

- Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms.

- The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.

- Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. Species is the most fundamental unit of classification.

THE INTERDEPENDENCE OF ORGANISMS

- The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere.

- Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers.

- Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.

- Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.

- Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.

MATTER, ENERGY, AND ORGANIZATION IN LIVING SYSTEMS

- All matter tends toward more disorganized states. Living systems require a continuous input of energy to maintain their chemical and physical organizations. With death, and the cessation of energy input, living systems rapidly disintegrate.

- The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules. These molecules can be used to assemble larger molecules with biological activity (including proteins, DNA, sugars, and fats). In addition, the energy stored in bonds between the atoms (chemical energy) can be used as sources of energy for life processes.

- The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed. Cells usually store this energy temporarily in phosphate bonds of a small high-energy compound called ATP.

- The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.

- The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.

- As matter and energy flows through different levels of organization of living systems--cells, organs, organisms, communities--and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change.

THE BEHAVIOR OF ORGANISMS

- Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them.

- Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.

- Like other aspects of an organism's biology, behaviors have evolved through natural selection. Behaviors often have an adaptive logic when viewed in terms of evolutionary principles.

- Behavioral biology has implications for humans, as it provides links to psychology, sociology, and anthropology.

3) Earth and Space Science

ENERGY IN THE EARTH SYSTEM

- Earth systems have internal and external sources of energy, both of which create heat. The sun is the major external source of energy. Two primary sources of internal energy are the decay of radioactive isotopes and the gravitational energy from the earth's original formation.

- The outward transfer of earth's internal heat drives convection circulation in the mantle that propels the plates comprising earth's surface across the face of the globe.

- Heating of earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

- Global climate is determined by energy transfer from the sun at and near the earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover and the earth's rotation, and static conditions such as the position of mountain ranges and oceans.

GEOCHEMICAL CYCLES

- The earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs. Each element on earth moves among reservoirs in the solid earth, oceans, atmosphere, and organisms as part of geochemical cycles.

- Movement of matter between reservoirs is driven by the earth's internal and external sources of energy. These movements are often accompanied by a change in the physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as carbon dioxide gas, in water as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life.

THE ORIGIN AND EVOLUTION OF THE EARTH SYSTEM

- The sun, the earth, and the rest of the solar system formed from a nebular cloud of dust and gas 4.6 billion years ago. The early earth was very different from the planet we live on today.

- Geologic time can be estimated by observing rock sequences and using fossils to correlate the sequences at various locations. Current methods include using the known decay rates of radioactive isotopes present in rocks to measure the time since the rock was formed.

- Interactions among the solid earth, the oceans, the atmosphere, and organisms have resulted in the ongoing evolution of the earth system. We can observe some changes such as earthquakes and volcanic eruptions on a human time scale, but many processes such as mountain building and plate movements take place over hundreds of millions of years.

- Evidence for one-celled forms of life--the bacteria--extends back more than 3.5 billion years. The evolution of life caused dramatic changes in the composition of the earth's atmosphere, which did not originally contain oxygen.

THE ORIGIN AND EVOLUTION OF THE UNIVERSE

- The origin of the universe remains one of the greatest questions in science. The "big bang" theory places the origin between 10 and 20 billion years ago, when the universe began in a hot dense state; according to this theory, the universe has been expanding ever since.

- Early in the history of the universe, matter, primarily the light atoms hydrogen and helium, clumped together by gravitational attraction to form countless trillions of stars. Billions of galaxies, each of which is a gravitationally bound cluster of billions of stars, now form most of the visible mass in the universe.

- Stars produce energy from nuclear reactions, primarily the fusion of hydrogen to form helium. These and other processes in stars have led to the formation of all the other elements.

4) Chemistry

STRUCTURE OF ATOMS

- Matter is made of minute particles called atoms, and atoms are composed of even smaller components. These components have measurable properties, such as mass and electrical charge. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric force between the nucleus and electrons holds the atom together.

- The atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that differ in the number of neutrons, these atoms are called different isotopes of the element.

- The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars.

STRUCTURE AND PROPERTIES OF MATTER

- Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. These outer electrons govern the chemical properties of the element.

- An element is composed of a single type of atom. When elements are listed in order according to the number of protons (called the atomic number), repeating patterns of physical and chemical properties identify families of elements with similar properties. This "Periodic Table" is a consequence of the repeating pattern of outermost electrons and their permitted energies.

- Bonds between atoms are created when electrons are paired up by being transferred or shared. A substance composed of a single kind of atom is called an element. The atoms may be bonded together into molecules or crystalline solids. A compound is formed when two or more kinds of atoms bind together chemically.

- The physical properties of compounds reflect the nature of the interactions among its molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them.

- Solids, liquids, and gases differ in the distances and angles between molecules or atoms and therefore the energy that binds them together. In solids the structure is nearly rigid; in liquids molecules or atoms move around each other but do not move apart; and in gases molecules or atoms move almost independently of each other and are mostly far apart.

- Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life.

- Organic chemistry can be described by the structure and chemical properties of hydrocarbons, functional groups and other carbon containing compounds.

CHEMICAL REACTIONS

- Chemical reactions occur all around us, for example in health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies.

- Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog.

- A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, the burning and processing of fossil fuels, the formation of polymers, and explosions.

- Chemical reactions can take place in time periods ranging from the few femtoseconds (10^{-15}seconds) required for an atom to move a fraction of a chemical bond distance to geologic time (scales of billions of years). Reaction rates depend on how often the reacting atoms and molecules encounter one another, on the temperature, and on the properties--including shape--of the reacting species.

- Catalysts, such as metal surfaces, accelerate chemical reactions. Chemical reactions in living systems are catalyzed by protein molecules called enzymes.

- Stoichiometric calculations are used to predict limiting reactants, and amount of products and reactants in chemical reactions.

- Laboratory safety requires current knowledge of potential hazards, including those related to chemical compounds, their interactions and appropriate laboratory equipment.

CONSERVATION OF ENERGY AND THE INCREASE IN DISORDER

- The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered.

- All energy can be considered to be either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; or energy contained by a field, such as electromagnetic waves.

- Heat consists of random motion and the vibrations of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion.

INTERACTIONS OF ENERGY AND MATTER

- Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.

- Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.

- Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance.

- In some materials, such as metals, electrons flow easily, whereas in insulating materials such as glass they can hardly flow at all. Semiconducting materials have intermediate behavior. At low temperatures some materials become superconductors and offer no resistance to the flow of electrons.

5) Physics

MEASUREMENT AND PROPERTIES OF MATTER

- Matter is made of minute particles called atoms, and atoms are composed of even smaller components. These components have measurable properties, such as mass and electrical charge.

- Objects can be described in terms of six observable and measurable quantities: mass, charge, pressure, volume, temperature, and density. Appropriate laboratory tools and instruments can be used to measure or determine these quantities for a given sample.

- The measurable physical quantities of an object and interactions with its surroundings must be described using correct and appropriate units. The base (fundamental) units in the metric (SI) system are the kilogram, second, meter, Kelvin, candela, Ampere, and mole. Other quantities used in physical descriptions use derived units that are combinations of base units.

- Measurements differ in their precision and accuracy, but all measurement involves uncertainty.

MOTION AND MECHANICS

- Both scalar (physical measurements that do not involve direction) and vector (physical measurements that depend on direction) quantities are needed to fully describe and measure motion.

- The linear motion of an object can be described using the equations of motion known as kinematic equations. These equations can be applied for motion occurring in one, two, or three dimensions. An understanding of vectors and simple vector calculations are needed for describing two- and three- dimensional (including circular) motion.

- Objects change their motion only when a net force is applied. Newton's Three Laws of Motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship $F = ma$, which is independent of the nature of the force. Whenever one object exerts a force on a second object, a force equal in magnitude and opposite in direction is exerted on the first object.

- Newton's Laws and the kinematics equations can be combined to describe and predict the motion of an object.

- Gravitation is a universal force that any mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them. Because the gravitational force can act at a distance, it is known as a field force.

- The forces acting in a system can be used to determine the work involved. Work performed on or by a system is a measure of the energy provided to or by the system. The measure of work or energy per time is power. These concepts can be applied to mechanical, electromagnetic, and nuclear forces.

- Energy is a unifying concept in the study of physics. Energy can exist in various manifestations including kinetic, potential, thermal, chemical, nuclear, and electromagnetic. The law of conservation of energy holds that the total energy of a system must remain constant; energy in the system can be transferred from one form to another.

- The momentum of a system in motion is the product of the mass and the velocity. The total vector momentum of a system is always conserved.

- Newton's Laws, conservation of energy, and conservation of momentum are also used to analyze rotational motion.

- Rotational mechanics is described by quantities and formulas that are analogous to rectilinear counterparts. The conservation of angular momentum is particularly useful in describing a wide range of natural and engineered phenomena.

- Fluid statics and fluid dynamics are summarized using the concepts of Pascal, Archimedes, and Bernoulli.

CONSERVATION OF ENERGY AND THE INCREASE IN DISORDER

- The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, energy can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered.
- All energy can be considered to be either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; or energy contained by a field, such as electromagnetic waves.
- The kinetic molecular theory describes thermal energy as random motion and vibrations of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion.
- Everything tends to become less organized and less orderly over time. Thus, in all energy transfers, the overall effect is that the energy is spread out uniformly. Examples are the transfer of energy from hotter to cooler objects by conduction, radiation, or convection and the warming of our surroundings when we burn fuels.
- The laws of thermodynamics explain and predict the behavior of most thermal systems.
- Atomic interaction of particles are responsible for macroscopic thermal properties of materials such as heat capacity, thermal expansion, thermal conduction, etc.

OSCILLATIONS AND THE BEHAVIOR OF WAVES

- Simple harmonic motions are caused by a restoring force proportional to the displacement from equilibrium and can be described by sine or cosine graphs. Simple pendulums and masses on springs are common applications of systems that can be described or approximated by simple harmonic motion.
- Waves, including waves on water, sound, and light waves, transfer energy when they interact with matter.
- The behavior of waves can be described by reflection, refraction, diffraction, interference, polarization, dispersion, transmission, and absorption.
- The perceptions and properties associated with sound and light are determined by the characteristics of the waves that carry them.
- The concepts of wave motions can be used to predict both conceptually and quantitatively the behavior of simple optical systems.

THE NATURE OF ELECTRICITY AND MAGNETISM

- All electric and magnetic phenomena are caused by the presence or motion of charge.
- The electrical force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. The strength of the force is proportional to the charges, and as with gravitation, inversely proportional to the square of the distance between them.
- Coulomb’s Law and the concepts of field forces and potential energy can be used to explain electrostatic effects. Between any two charges, electric force is vastly greater than the gravitational force.
- Ohm’s Law and Watt’s Law can be used to explain the behavior of simple circuits. These laws in combination with Kirchhoff’s laws can be used to analyze series and parallel circuits.
- A moving charge creates magnetic effects and experiences a force if it moves through an external magnetic field.
- Ampere’s Law and Faraday’s Law can be used to explain the operation of motors and generators.

- Electromagnetic waves result when a charged object is accelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays.

- In some materials, such as metals, electrons flow easily, whereas in insulating materials such as glass they can hardly flow at all. Semiconducting materials have intermediate behavior. At low temperatures some materials become superconductors and offer no resistance to the flow of electrons.

ATOMIC AND SUBATOMIC PHYSICS

- Almost all of the mass of an atom is contained in the protons and neutrons in the nucleus, while the electrons in their orbits determine the size of the atom. The atom can be thought of as mainly empty space

- The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength. Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance.

- A strong nuclear force overcomes Coulomb repulsion in stable nuclei. The degree of stability is expressed as the average binding energy per nucleon.

- Radioactive isotopes are unstable and undergo spontaneous nuclear reactions. Some nuclei that are unstable decay by releasing alpha, beta, or gamma emissions to form more stable daughter nuclei. The speed with which these processes proceed can be described by decay rates and half lives.

- Because midsize nuclei are the most stable, both fusion of light nuclei or fission of large nuclei can release energy. The amount of energy released per particle involved is much greater for nuclear changes than for chemical or physical changes

HISTORICAL PESPECTIVE

The development of the understanding of physics has been a global academic pursuit over the course of many centuries. This sequential development has depended on the work of early astronomers, the contributions of Galileo and Newton in mechanics, the work of Ampere, Faraday, and Maxwell in electromagnetism, the numerous contributions of Einstein in the transition to modern physics, the contributions of Thomson, Rutherford, and Bohr in atomic physics, the discoveries of Curie, Meitner, and Fermi in nuclear physics, and many others.

Appendix D (From: NRC, National Science Education Standards)
Science and Technology

ABILITIES OF TECHNOLOGICAL DESIGN

IDENTIFY A PROBLEM OR DESIGN AN OPPORTUNITY

Students should be able to identify new problems or needs and to change and improve current technological designs.

PROPOSE DESIGNS AND CHOOSE BETWEEN ALTERNATIVE SOLUTIONS

Students should demonstrate thoughtful planning for a piece of technology or technique. Students should be introduced to the roles of models and simulations in these processes.

IMPLEMENT A PROPOSED SOLUTION

A variety of skills can be needed in proposing a solution depending on the type of technology that is involved. The construction of artifacts can require the skills of cutting, shaping, treating, and joining common materials--such as wood, metal, plastics, and textiles. Solutions can also be implemented using computer software.

EVALUATE THE SOLUTION AND ITS CONSEQUENCES

Students should test any solution against the needs and criteria it was designed to meet. At this stage, new criteria not originally considered may be reviewed.

COMMUNICATE THE PROBLEM, PROCESS, AND SOLUTION

Students should present their results to students, teachers, and others in a variety of ways, such as orally, in writing, and in other forms--including models, diagrams, and demonstrations.

UNDERSTANDINGS ABOUT SCIENCE AND TECHNOLOGY

- Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations. Many scientific investigations require the contributions of individuals from different disciplines, including engineering. New disciplines of science, such as geophysics and biochemistry, often emerge at the interface of two older disciplines.

- Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research.

- Creativity, imagination, and a good knowledge base are all required in the work of science and engineering.

- Science and technology are pursued for different purposes. Scientific inquiry is driven by the desire to understand the natural world, and technological design is driven by the need to meet human needs and solve human problems. Technology, by its nature, has a more direct effect on society than science because its purpose is to solve human problems, help humans adapt, and fulfill human aspirations. Technological solutions may create new problems. Science, by its nature, answers questions that may or may not directly influence humans. Sometimes scientific advances challenge people's beliefs and practical explanations concerning various aspects of the world.

- Technological knowledge is often not made public because of patents and the financial potential of the idea or invention. Scientific knowledge is made public through presentations at professional meetings and publications in scientific journals.

UNDERSTANDINGS ABOUT LABORATORY MANAGEMENT

- Scientists understand Occupational Safety and Health Administration (OSHA) rules and regulations and how they apply in the science laboratory.

- Scientists know and apply the necessary safety regulations in the storage, use and care of the materials used in the laboratory.

- Scientists adhere to the safety rules and guidelines established by the national organizations, as well as local and state regulatory agencies.

- Implementation and use of safety guidelines, including the use of appropriate safety equipment are critical components of scientific inquiry.

Appendix E (From: NRC, National Science Education Standards)
Science in Personal and Social Perspectives

PERSONAL AND COMMUNITY HEALTH

- Hazards and the potential for accidents exist. Regardless of the environment, the possibility of injury, illness, disability, or death may be present. Humans have a variety of mechanisms--sensory, motor, emotional, social, and technological--that can reduce and modify hazards.

- The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism. Many diseases can be prevented, controlled, or cured. Some diseases, such as cancer, result form specific body dysfunctions and cannot be transmitted.

- Personal choice concerning fitness and health involves multiple factors. Personal goals, peer and social pressures, ethnic and religious beliefs, and understanding of biological consequences can all influence decisions about health practices.

- An individual's mood and behavior may be modified by substances. The modification may be beneficial or detrimental depending on the motives, type of substance, duration of use, pattern of use, level of influence, and short- and long-term effects. Students should understand that drugs can result in physical dependence and can increase the risk of injury, accidents, and death.

- Selection of foods and eating patterns determine nutritional balance. Nutritional balance has a direct effect on growth and development and personal well-being. Personal and social factors--such as habits, family income, ethnic heritage, body size, advertising, and peer pressure--influence nutritional choices.

- Families serve basic health needs, especially for young children. Regardless of the family structure, individuals have families that involve a variety of physical, mental, and social relationships that influence the maintenance and improvement of health.

- Sexuality is basic to the physical, mental, and social development of humans. Students should understand that human sexuality involves biological functions, psychological motives, and cultural, ethnic, religious, and technological influences. Sex is a basic and powerful force that has consequences to individuals' health and to society. Students should understand various methods of controlling the reproduction process and that each method has a different type of effectiveness and different health and social consequences.

POPULATION GROWTH

- Populations grow or decline through the combined effects of births and deaths, and through emigration and immigration. Populations can increase through linear or exponential growth, with effects on resource use and environmental pollution.

- Various factors influence birth rates and fertility rates, such as average levels of affluence and education, importance of children in the labor force, education and employment of women, infant mortality rates, costs of raising children, availability and reliability of birth control methods, and religious beliefs and cultural norms that influence personal decisions about family size.

- Populations can reach limits to growth. Carrying capacity is the maximum number of individuals that can be supported in a given environment. The limitation is not the availability of space, but the number of people in relation to resources and the capacity of earth systems to support human beings. Changes in technology can cause significant changes, either positive or negative, in carrying capacity.

NATURAL RESOURCES

- Human populations use resources in the environment in order to maintain and improve their existence. Natural resources have been and will continue to be used to maintain human populations.

- The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources and it depletes those resources that cannot be renewed.

- Humans use many natural systems as resources. Natural systems have the capacity to reuse waste, but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically.

ENVIRONMENTAL QUALITY

- Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans.

- Materials from human societies affect both physical and chemical cycles of the earth.

- Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, over consumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and the different ways humans view the earth.

NATURAL AND HUMAN-INDUCED HAZARDS

- Normal adjustments of earth may be hazardous for humans. Humans live at the interface between the atmosphere driven by solar energy and the upper mantle where convection creates changes in the earth's solid crust. As societies have grown, become stable, and come to value aspects of the environment, vulnerability to natural processes of change has increased.

- Human activities can enhance potential for hazards. Acquisition of resources, urban growth, and waste disposal can accelerate rates of natural change.

- Some hazards, such as earthquakes, volcanic eruptions, and severe weather, are rapid and spectacular. But there are slow and progressive changes that also result in problems for individuals and societies. For example, change in stream channel position, erosion of bridge foundations, sedimentation in lakes and harbors, coastal erosions, and continuing erosion and wasting of soil and landscapes can all negatively affect society.

- Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students should understand the costs and trade-offs of various hazards--ranging from those with minor risk to a few people to major catastrophes with major risk to many people. The scale of events and the accuracy with which scientists and engineers can (and cannot) predict events are important considerations.

SCIENCE AND TECHNOLOGY IN LOCAL, NATIONAL, AND GLOBAL CHALLENGES

- Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.

- Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science- and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges.

- Progress in science and technology can be affected by social issues and challenges. Funding priorities for specific health problems serve as examples of ways that social issues influence science and technology.

- Individuals and society must decide on proposals involving new research and the introduction of new technologies into society. Decisions involve assessment of alternatives, risks, costs, and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them. Students should understand the appropriateness and value of basic questions--"What can happen?"--"What are the odds?"--and "How do scientists and engineers know what will happen?"

- Humans have a major effect on other species. For example, the influence of humans on other organisms occurs through land use--which decreases space available to other species--and pollution--which changes the chemical composition of air, soil, and water.

Appendix F
Science Habits of Mind

The term habits of mind refers to those values, attitudes, and skills that relate to a person's knowledge and learning and ways of thinking about science. The teachers of science should nurture science habits of mind among students by:

Values and Attitudes in Science

- helping people qualitatively and quantitatively and make sense of their natural world.
- fostering the attitudes of curiosity, openness to new ideas, and informed skepticism.
- developing positive attitudes about science.

Estimation and Computation Skills

- including the use of estimation skills to have a sense of what an adequate degree of precision is in a particular situation and an understanding of the purpose of the calculation.
- providing experience with basic number skills and computations in meaningful contexts.
- including an understanding and appropriate use of the calculator.

Manipulation and Observation Skills

- providing opportunities to handle common materials and tools for dealing with household and everyday technologies and appropriate scientific laboratory equipment for making careful observations, and for handling information which might include:
- Keeping a science journal for observations.
- Entering, storing, and retrieving computer information.
- Using appropriate instruments to make measurements of length, volume, weight, time interval, and temperature.
- Taking readings from standard meter displays.

Communication Skills

- providing opportunities to communicate ideas and share information with accuracy and clarity and to read and listen with understanding.

Critical-Response Skills

- allowing students to respond to scientific assertions and arguments critically, deciding what to pay attention and what to ignore.
- allowing students to apply those same critical skills to their own observations, arguments, and conclusions.

Appendix G

Developmentally Appropriate Content

As this document defines the knowledge, dispositions, and performances expected of Indiana teachers of science, the *Indiana Academic Standards* define what students are to know and be able to do in science. By defining the skills and knowledge base expected of students at the Kindergarten/Primary, the Upper Elementary/Intermediate, the Middle/Junior High, and the High School grades, the *Indiana Academic Standards* make explicit what understandings and skills in science are appropriate for students at certain developmental levels.

By using the *Indiana Academic Standards* to guide his or her understanding of what students can master at certain levels, the teacher of science will know what subject matter should be introduced at a particular level, and what portion of that subject matter can be mastered at a particular level. Specifically this means:

- The early childhood teacher will be working to ensure that students master the standards defined for the Kindergarten/Primary grades while working to introduce some or many of the ideas that students will be expected to master at the Upper Elementary/Intermediate grades.
- The middle childhood teacher will be working to ensure that students master the standards defined for the Upper Elementary/Intermediate grades while working to introduce some or many of the ideas that students will be expected to master at the Middle/Junior High grades.
- The early adolescent teacher will be working to ensure that students master the standards defined for the Middle/Junior High grades while working to introduce some or many of the ideas that students will be expected to master at the High School level.
- The adolescent and young adult teacher will be working to ensure that students master the standards defined for the High School grades while working to introduce some or many of the ideas that students will be expected to master in post-secondary studies.

Through this process, the teacher will be part of a larger curriculum process that provides continuity in how skills and concepts are being taught. Without this continuity, a school system cannot ensure that students are being exposed to subject matter which is appropriate for their developmental level, thereby setting students up for failure before they even begin. The teacher of science should be committed to being part of a system where students have the opportunity to learn content that builds upon what they already know and prepares the foundation for what they will learn in the future.

This page printed from: http://www.doe.state.in.us/dps/standards/Scienceteachersapproved4_28_04_2.html

Technology Standards
and Performance Indicators for Teachers
"ISTE Standards"

http://cnets.iste.org/index3.html

The ISTE National Educational Technology Standards for Teachers (NETS-T), which focus on preservice teacher education, define the fundamental concepts, knowledge, skills, and attitudes for applying technology in educational settings. All candidates seeking certification or endorsements in teacher preparation should meet these educational technology standards. It is the responsibility of faculty across the university and at cooperating schools to provide opportunities for teacher candidates to meet these standards.

Performance indicators for each standard provide specific outcomes to be measured when developing a set of assessment tools. The six standards areas with performance indicators are designed to be general enough to be customized to fit state, university, or district guidelines and yet specific enough to define the scope of the topic. The standards and the performance indicators also provide guidelines for teachers currently in the classroom.

I. TECHNOLOGY OPERATIONS AND CONCEPTS

Teachers demonstrate a sound understanding of technology operations and concepts. Teachers

A. demonstrate introductory knowledge, skills, and understanding of concepts related to technology (as described in the ISTE National Education Technology A Standards for Students in Appendix A).

B. demonstrate continual growth in technology knowledge and skills to stay abreast of current and emerging technologies.

II. PLANNING AND DESIGNING LEARNING ENVIRONMENTS AND EXPERIENCES.

Teachers plan and design effective learning environments and experiences supported by technology. Teachers:

A. design developmentally appropriate learning opportunities that apply technology-enhanced instructional strategies to support the diverse needs of learners.

B. apply current research on teaching and learning with technology when planning learning environments and experiences.

C. identify and locate technology resources and evaluate them for accuracy and suitability.

D. plan for the management of technology resources within the context of learning activities.

E. plan strategies to manage student learning in a technology-enhanced environment.

III. TEACHING, LEARNING, AND THE CURRICULUM.

Teachers implement curriculum plans that include methods and strategies for applying technology to maximize student learning. Teachers:

A. facilitate technology-enhanced experiences that address content standards and student technology standards.

B. use technology to support learner-centered strategies that address the diverse needs of students.

C. apply technology to develop students' higher order skills and creativity.

D. manage student learning activities in a technology-enhanced environment.

IV. ASSESSMENT AND EVALUATION.

Teachers apply technology to facilitate a variety of effective assessment and evaluation strategies. Teachers:

A. apply technology in assessing student learning of subject matter using a variety of assessment techniques.

B. use technology resources to collect and analyze data, interpret results, and communicate findings to improve instructional practice and maximize student learning.

C. apply multiple methods of evaluation to determine students' appropriate use of technology resources for learning, communication, and productivity.

V. PRODUCTIVITY AND PROFESSIONAL PRACTICE.

Teachers use technology to enhance their productivity and professional practice. Teachers:

A. use technology resources to engage in ongoing professional development and lifelong learning.

B. continually evaluate and reflect on professional practice to make informed decisions regarding the use of technology in support of student learning.

C. apply technology to increase productivity.

D. use technology to communicate and collaborate with peers, parents, and the larger community in order to nurture student learning.

VI. SOCIAL, ETHICAL, LEGAL, AND HUMAN ISSUES.

Teachers understand the social, ethical, legal, and human issues surrounding the use of technology in PK-12 schools and apply those principles in practice. Teachers:

A. model and teach legal and ethical practice related to technology use.

B. apply technology resources to enable and empower learners with diverse backgrounds, characteristics, and abilities.

C. identify and use technology resources that affirm diversity.

D. promote safe and healthy use of technology resources.

E. facilitate equitable access to technology resources for all students.

Appendix A
Technology Foundation Standards for Students

The technology foundation standards for students are divided into six broad categories. Standards within each category are to be introduced, reinforced, and mastered by students. These categories provide a framework for linking performance indicators within the Profiles for Technology Literate Students to the standards. Teachers can use these standards and profiles as guidelines for planning technology-based activities in which students achieve success in learning, communication, and life skills.

1. Basic operations and concepts
   - Students demonstrate a sound understanding of the nature and operation of technology systems.
   - Students are proficient in the use of technology.
2. Social, ethical, and human issues
   - Students understand the ethical, cultural, and societal issues related to technology.
   - Students practice responsible use of technology systems, information, and software.
   - Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.
3. Technology productivity tools
   - Students use technology tools to enhance learning, increase productivity, and promote creativity.
   - Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works.
4. Technology communications tools
   - Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.
   - Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.
5. Technology research tools
   - Students use technology to locate, evaluate, and collect information from a variety of sources.
   - Students use technology tools to process data and report results.
   - Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.
6. Technology problem-solving and decision-making tools
   - Students use technology resources for solving problems and making informed decisions.
   - Students employ technology in the development of strategies for solving problems in the real world.

Appendix B
Technology Performance Indicators for Teachers

Today's teacher preparation programs provide a variety of alternative paths to initial licensure. They address economic conditions, needs of prospective teachers, and the demands of employing school districts. Regardless of the configuration of the program, all teachers must have opportunities for experiences that prepare them to meet technology standards. The existence of many types of programs virtually ensures that there will be no one method for providing learning experiences to meet these standards.

The Technology Performance Profiles for Teacher Preparation suggest ways programs can incrementally examine how well candidates meet the standards. The Profiles correspond to four phases in the typical preparation of a teacher. The Profiles are not meant to be prescriptive or lockstep; they are specifically designed to be fluid in providing guidelines for programs to create a set of benchmarks in planning and assessment that align with unique program design.

GENERAL PREPARATION PERFORMANCE PROFILE[1]

Students may be in their major or minor course of study. They may be at the lower division level or may have received skill development through on-the-job training, obtaining a degree or experience in a nontraditional program. Typically, the university arts and sciences areas provide the experiences defined in this Profile. Programs may have multiple ways for candidates to demonstrate that they are able to perform the tasks that go beyond the classroom setting. Upon completion of the general preparation component of their programs, prospective teachers should be able to meet the competencies described in this Profile.

Upon completion of the general preparation component of their program, prospective teachers:

1. demonstrate a sound understanding of the nature an operation of technology systems. (I)[2]

2. demonstrate proficiency in the use of common input and output devices; solve routine hardware and software problems; and make informed choices about technology systems, resources, and services. (I)

3. use technology tools and information resources to increase productivity, promote creativity, and facilitate academic learning. (I, III, IV, V)

4. use content-specific tools (e.g., software, simulation, environmental robes, graphing calculators, exploratory environments, Web tools) to support learning and research. (I, III, V)

5. use technology resources to facilitate higher order and complex thinking skills, including problem solving, critical thinking, informed decision making, knowledge construction, and creativity. (I, III, V)

6. collaborate in constructing technology-enhanced models, preparing publications, and producing other creative works using productivity tools. (I, V)

[1] ISTE standards are written at four levels: General, Professional Preparation, Student Teaching, and First Year Teacher. All levels address all standards but at increasingly higher levels of sophistication. The ISTE web site (http://cnets.iste.org/index3.html) provides scenarios of pre- and in-service teachers performing at each of these four levels.

[2] Numbers in parentheses following each performance indicator refer to the standards category to which the performance is linked. The standards categories are:

I. Technology operations and concepts
II. Planning and Designing Learning Environments and Experiences
III. Teaching, Learning, and the curriculum
IV. Assessment and Evaluation
V. Productivity and Professional Practice
VI. Social, Ethical, Legal, and Human Issues

7. use technology to locate, evaluate, and collect information from a variety of sources. (I, IV, V)

8. use technology tools to process data and report results. (I, III, IV, V)

9. use technology in the development of strategies for solving problems in the real world. (I, III, V)

10. observe and experience the use of technology in their major field of study. (III, V)

11. use technology tools and resources for managing and communicating information (e.g., finances, schedules, addresses, purchases, correspondence). (I, V)

12. evaluate and select new information resources and technological innovations based on their appropriateness to specific tasks. (I, III, IV, V)

13. use a variety of media and formats, including telecommunications, to collaborate, publish, and interact with peers, experts, and other audiences. (I, V)

14. demonstrate an understanding of the legal, ethical, cultural, and societal issues related to technology. (VI)

15. exhibit positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity. (V, VI)

16. discuss diversity issues related to electronic media. (I, VI)

17. discuss the health and safety issues related to technology use. (VI)

PROFESSIONAL PREPARATION PERFORMANCE PROFILE

Students have been admitted to a professional core of courses or experiences taught by the school or college of education or professional education faculty. Experiences in this Profile are part of professional education coursework that may also include integrated field work. The school or college of education or professional development school is typically responsible for preservice teachers having the experiences described in this Profile. Prior to the culminating student teaching or internship experience, prospective teachers should be able to meet the competencies described in this Profile.

Prior to the culminating student teaching or internship experience, prospective teachers:

1. identify the benefits of technology to maximize student learning and facilitate higher order thinking skills. (I, III)

2. differentiate between appropriate and inappropriate uses of technology for teaching and learning while using electronic resources to design and implement learning activities. (II, III, V, VI)

3. identify technology resources available in schools and analyze how accessibility to those resources affects planning for instruction. (I, II)

4. identify, select, and use hardware and software technology resources specially designed for use by PK-12 students to meet specific teaching and learning objectives. (I, II)

5. plan for the management of electronic instructional resources within a lesson design by identifying potential problems and planning for solutions. (II)

6. identify specific technology applications and resources that maximize student learning, address learner needs, and affirm diversity. (III, VI)

7. design and teach technology-enriched learning activities that connect content standards with student technology standards and meet the diverse needs of students. (II, III, IV, VI)

8. design and peer teach a lesson that meets content area standards and reflects the current best practices in teaching and learning with technology. (II, III)

9. plan and teach student-centered learning activities and lessons in which students apply technology tools and resources. (II, III)

10. research and evaluate the accuracy, relevance, appropriateness, comprehensiveness, and bias of electronic information resources to be used by students. (II, IV, V, VI)

11. discuss technology-based assessment and evaluation strategies. (IV)

12. examine multiple strategies for evaluating technology-based student products and the processes used to create those products. (IV)

13. examine technology tools used to collect, analyze, interpret, represent, and communicate student performance data.(I, IV)

14. integrate technology-based assessment strategies and tools into plans for evaluating specific learning activities. (IV)

15. develop a portfolio of technology-based products from coursework, including the related assessment tools. (IV, V)

16. identify and engage in technology-based opportunities for professional education and lifelong learning, including the use of distance education. (V)

17. apply online and other technology resources to support problem solving and related decision making for maximizing student learning. (III, V)

18. participate in online professional collaborations with peers and experts. (III, V)

19. use technology productivity tools to complete required professional tasks. (V)

20. identify technology-related legal and ethical issues, including copyright, privacy, and security of technology systems, data, and information. (VI)

21. examine acceptable use policies for the use of technology in schools, including strategies for addressing threats to security of technology systems, data, and information. (VI)

22. identify issues related to equitable access to technology in school, community, and home environments. (VI)

23. identify safety and health issues related to technology use in schools. (VI)

24. identify and use assistive technologies to meet the special physical needs of students. (VI)

STUDENT TEACHING/INTERNSHIP PERFORMANCE PROFILE

Students have completed or are finalizing their professional education coursework and are out in the classroom completing their final student teaching or intern teaching experience with extensive time spent with students. These individuals will obtain their initial licensure or credential required for a teaching job at the completion of this phase of their education. They are being supervised by a mentor or master teacher on a consistent basis. Upon completion of the culminating student teaching or internship experience, and at the point of initial licensure, teachers should meet the competencies described in this Profile.

Upon completion of the culminating student teaching or internship experience, and at the point of initial licensure, teachers:

1. apply troubleshooting strategies for solving routine hardware and software problems that occur in the classroom. (I)

2. identify, evaluate, and select specific technology resources available at the school site and district level to support a coherent lesson sequence. (II, III)

3. design, manage, and facilitate learning experiences using technology that affirm diversity and provide equitable access to resources. (II, VI)

4. create and implement a well-organized plan to manage available technology resources, provide equitable access for all students, and enhance learning outcomes. (II, III)

5. design and facilitate learning experiences that use assistive technologies to meet the special physical needs of students. (II, III)

6. design and teach a coherent sequence of learning activities that integrates appropriate use of technology resources to enhance student academic achievement and technology proficiency by connecting district, state, and national curriculum standards with student technology standards (as defined in the ISTE National Educational Technology Standards for Students). (II, III)

7. design, implement, and assess learner-centered lessons that are based on the current best practices on teaching and learning with technology and that engage, motivate, and encourage self-directed student learning. (II, III, IV, V)

8. guide collaborative learning activities in which students use technology resources to solve authentic problems in the subject area(s). (III)

9. develop and use criteria for ongoing assessment of technology-based student products and the processes used to create those products. (IV)

10. design an evaluation plan that applies multiple measures and flexible assessment strategies to determine students' technology proficiency and content area learning. (IV)

11. use multiple measures to analyze instructional practices that employ technology to improve planning, instruction, and management. (II, III, IV)

12. apply technology productivity tools and resources to collect, analyze, and interpret data and to report results to parents and students. (III, IV)

13. select and apply suitable productivity tools to complete educational and professional tasks. (II, III, V)

14. model safe and responsible use of technology and develop classroom procedures to implement school and district technology acceptable use policies and data security plans. (V, VI)

15. participate in online professional collaboration with peers and experts as part of a personally designed plan, based on self-assessment, for professional growth in technology. (V)

FIRST-YEAR TEACHING PERFORMANCE PROFILE

Teachers have completed their formal teacher preparation program and are in their first year of independent teaching. They are typically in control of their own classroom and are under contract with a school district. Teachers at this stage, as with any teacher in the building, are supervised by their school administrator. The novice teacher may be part of a beginning teacher support program and may be receiving coaching and mentoring. Upon completion of the first year of teaching, teachers should meet the competencies described in this Profile.

Upon completion of the first year of teaching, teachers:

1. assess the availability of technology resources at the school site, plan activities that integrate available resources, and develop a method for obtaining the additional necessary software and hardware to support the specific learning needs of students in the classroom. (I, II, IV)

2. make appropriate choices about technology systems, resources, and services that are aligned with district and state standards. (I, II)

3. arrange equitable access to appropriate technology resources that enable students to engage successfully in learning activities across subject/content areas and grade levels. (II, III, VI)

4. engage in ongoing planning of lesson sequences that effectively integrate technology resources and are consistent with current best practices for integrating the learning of subject matter and student technology standards (as defined in the ISTE National Educational Technology Standards for Students). (II, III)

5. plan and implement technology-based learning activities that promote student engagement in analysis, synthesis, interpretation, and creation of original products. (II, III)

6. plan for, implement, and evaluate the management of student use of technology resources as part of classroom operations and in specialized instructional situations. (I, II, III, IV)

7. implement a variety of instructional technology strategies and grouping strategies (e.g., whole group, collaborative, individualized, and learner centered) that include appropriate embedded assessment for meeting the diverse needs of learners. (III, IV)

8. facilitate student access to school and community resources that provide technological and discipline-specific expertise. (III)

9. teach students methods and strategies to assess the validity and reliability of information gathered through technological means. (II, IV)

10. recognize students' talents in the use of technology and provide them with opportunities to share their expertise with their teachers, peers, and others. (II, III, V)

11. guide students in applying self — and peer-assessment tools to critique student-created technology products and the process used to create those products. (IV)

12. facilitate students' use of technology that addresses their social needs and cultural identity and promotes their interaction with the global community. (III, VI)

13. use results from assessment measures (e.g., learner profiles, computer-based testing, electronic portfolios) to improve instructional planning, management, and implementation of learning strategies. (II, IV)

14. use technology tools to collect, analyze, interpret, represent, and communicate data (student performance and other information) for the purposes of instructional planning and school improvement. (IV)

15. use technology resources to facilitate communications with parents or guardians of students. (V)

16. identify capabilities and limitations of current and emerging technology resources and assess the potential of these systems and services to address personal, lifelong learning, and workplace needs. (I, IV, V)

17. participate in technology-based collaboration as part of continual and comprehensive professional growth to stay abreast of new and emerging technology resources that support enhanced learning for PK-12 students. (V)

18. demonstrate and advocate for legal and ethical behaviors among students, colleagues, and community members regarding the use of technology and information. (V, VI)

19. enforce classroom procedures that guide students' safe and healthy use of technology and that comply with legal and professional responsibilities for students needing assistive technologies. (VI)
20. advocate for equal access to technology for all students in their schools, communities, and homes. (VI)

21. implement procedures consistent with district and school policies that protect the privacy and security of student data and information. (VI)