A Review of the University of Wisconsin – Superior Secondary Education Science Curriculum

Anne Chelin, Secondary Education/Biology
Dr. Mary Balcer, Department of Biology and Earth Science

ABSTRACT

In the year 2004, there was a change in the requirements for teacher education students seeking licensure through the Wisconsin Department of Public Instruction (DPI). The DPI now requires all graduating teacher candidates to pass a Praxis II test in their discipline of study. In Wisconsin, the exam for all disciplines of science is the Praxis II-General Science Content Exam-10435. Due to the new testing requirements and the implementation of Wisconsin State Model Academics Standards, it became apparent that the current secondary education biology curriculum at the University of Wisconsin-Superior needed to be examined to assure that it was still a well rounded and effective educational experience for the teacher candidates. This study examines what course work is necessary for future instructors to effectively teach to the Wisconsin Model Academic Standards as well as to excel at the new Praxis II exam. The curricula from four colleges were compared to see how those schools are preparing their undergraduates for becoming Biology teachers at the secondary educational level. The University of Wisconsin-Superior, University of Wisconsin-Madison, University of Minnesota-Duluth, and College of St Scholastica were the schools examined. It was found that the University of Minnesota-Duluth has a well rounded and thorough curriculum for its graduating science teachers. The curriculum of University of Wisconsin-Superior would benefit by adding course work in physics, and earth science. The University of Wisconsin-Madison has two options for Biology major students. Both options contain a year of general physics and chemistry. Whereas neither option addresses physical science, earth science, or astronomy which are fundamental to both the State Model Academics and the Praxis II exam. While the College of St. Scholastica has clearly mapped out course work for their students attaining biology majors, they too have a curriculum that is lacking environmental science, evolution, astronomy, meteorology, physical science, and earth science. Students currently graduating from our local colleges are not fully prepared for the Wisconsin State Model Academic Standards or the Praxis II upon completion of those programs.
A Review of the University of Wisconsin-Superior Secondary Education Science Curriculum

Introduction

This study is a comprehensive examination of the current secondary education biology curriculum offered at the University of Wisconsin-Superior (UW-Superior) as well as a comparative look at the biological science teacher preparation programs of three other colleges. The guidelines for Wisconsin state teacher licensure have recently been modified. Formerly a graduating student of an accredited teacher preparation program would earn his/her teaching licensure upon graduation from the college. Under the new state guidelines known as PI 34, a graduating student is issued an Initial Educator License which he/she applies for after being hired for a first teaching position. This license is good for five years and is non-renewable, although it can be extended if the student teacher has not been employed as an educator for at least two consecutive years within the five year period. The program allows the Initial Educator to teach while he/she work on a Professional Development Plan (PDP). The PDP is intended to “assure the public that its professionals will maintain a commitment to the thoughtful acquisition of knowledge in their individual area(s) of endorsement as well as the application of best educational practices in their area(s) of expertise” (Wisconsin DPI, 2004).

The Initial Educator works with a mentor and selects a team who will be responsible for reviewing and approving the professional development goals (Teachers, 2000). The team will be comprised of a teacher of the same subject or of the same level, an administrator, and a higher education representative. The first year of employment as an educator is used for reflection and self assessment. A PDP is then developed and approved by the team for the new teacher to complete in a minimum of three and less than five years, after which they can be granted a Wisconsin State teaching license and title as “Initial Educator.” Upon receipt of this license, the Initial Educator achieves the title of “Professional Educator” and once again begins a new PDP with a team of three teachers selected by their peers. In ten years and upon completion of the second PDP, the educator can attain the title of “Master Educator.” The Master Educator also will be working with a team to aid them in completing their PDP. Personal growth and development will be an ongoing process during the full term of being an educator. According to Wisconsin Department of Public Instruction, “PI 34 provides the framework for professional development. It is up to the individual licensee to develop a Professional Development Plan that will assure that the Wisconsin teachers are broadly informed, highly committed, and disposed to actions that will keep Wisconsin schools places of willing and engaged learning for students and will result in enhanced student learning” (2004).
Another change that was implemented by PI 34 is that after September 1, 2004, student or pre-service teachers would be tested on their subject knowledge prior to licensure. Student teachers must pass the Praxis II test in their teachable major and minor before they are allowed to student teach, which is a graduation requirement for the teachers education programs. Educational Testing Service (ETS) states that the Praxis II exam for science “is designed to reflect current standards for knowledge, skills, and abilities in science education. . . . All the tests are not intended to assess teaching skills but rather to demonstrate the candidate’s fundamental knowledge in the major areas of science” (Study, 2002). There are many different Praxis II exams and Wisconsin requires all science teachers to take the General Science exam #10435; other states have different requirements. For example, teachers seeking certification for Biology in Minnesota are required to take the Biology Content Knowledge Praxis II exam number 20235, which covers the following materials (Study, 2002):

<table>
<thead>
<tr>
<th>I.) Basic Principles of Science</th>
<th>12 questions</th>
<th>8%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(History and Natural Science)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II.) Molecular and Cellular Biology</td>
<td>38 questions</td>
<td>25%</td>
</tr>
<tr>
<td>(Chemistry, Molecular and Cellular Biology)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III.) Classical Genetics and Evolution</td>
<td>23 questions</td>
<td>15%</td>
</tr>
<tr>
<td>IV.) Diversity of Life, Plants, and Animals (Plant and Animal Biology)</td>
<td>45 questions</td>
<td>30%</td>
</tr>
<tr>
<td>Sciences, General</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V.) Ecology</td>
<td>22 questions</td>
<td>15%</td>
</tr>
<tr>
<td>VI.) Science, and Society</td>
<td>10 questions</td>
<td>7%</td>
</tr>
<tr>
<td>(Methodology, Technology, Social, Political, Ethical Issues, Resource Ethical Issues, Resource Management).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In Minnesota, students in each of the other science disciplines will take the exam which corresponds with the content knowledge of their curriculum; for example: Chemistry will take Chemistry: Content Knowledge, exam number 20245; Physics students will takes Physics: Content Knowledge, exam number 10265. In an overall look at the exams required for teaching Biology (The Praxis, 2004), out of forty-five listed states, eight states require no content exam, and twenty-two require exam number 20235, Biology Content. Ten other states require Biology and General Science Content exams. Some states require only the Pedagogy exam and others have content exams and the additional component of a Pedagogy exam or the Principles of Learning exam. Colorado and
Wisconsin require only the General Science Content exam number 10435. Licensure for Colorado is for general science, whereas the licensure for Wisconsin is for individualized disciplines of science. The following chart, Table I, gives the required exams necessary for licensure in forty-five reporting states (The Praxis, 2004).
<table>
<thead>
<tr>
<th>State</th>
<th>DC</th>
<th>DE</th>
<th>CT</th>
<th>CO</th>
<th>CA</th>
<th>AR</th>
<th>AK</th>
<th>AL</th>
<th>Content</th>
<th>PPST</th>
<th>Praxis II Bio</th>
<th>Praxis II Bio</th>
<th>Other science related Praxis II exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>Biology</td>
<td>Biology</td>
<td>Biology</td>
<td>Science</td>
<td>Science</td>
<td>Life/Earth Science</td>
<td>Biology</td>
<td>Biology</td>
<td>Content</td>
<td>PPST</td>
<td>Praxis II Bio</td>
<td>Praxis II Bio</td>
<td>Other science related Praxis II exam</td>
</tr>
<tr>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>NA</td>
<td>NA</td>
<td>*</td>
<td>*</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20232</td>
<td>20232</td>
<td>20232</td>
<td>20232</td>
<td>20232</td>
<td>20232</td>
<td>20232</td>
<td>20232</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10435</td>
<td>10435</td>
<td>10435</td>
<td>10435</td>
<td>10435</td>
<td>10435</td>
<td>10435</td>
<td>10435</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA</td>
<td>Science</td>
<td>NA</td>
<td>NA</td>
<td>10435</td>
<td>10435</td>
<td>10435</td>
<td>10435</td>
<td>10435</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30234</td>
<td>30234</td>
<td>30234</td>
<td>30234</td>
<td>30234</td>
<td>30234</td>
<td>30234</td>
<td>30234</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pedagogy</td>
<td>Pedagogy</td>
<td>Pedagogy</td>
<td>Pedagogy</td>
<td>Pedagogy</td>
<td>Pedagogy</td>
<td>Pedagogy</td>
<td>Pedagogy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Principles/ Learning</td>
<td>Principles/ Learning</td>
<td>Principles/ Learning</td>
<td>Principles/ Learning</td>
<td>Principles/ Learning</td>
<td>Principles/ Learning</td>
<td>Principles/ Learning</td>
<td>Principles/ Learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table I. Praxis Exam Requirements by State for Teaching Licensure
<table>
<thead>
<tr>
<th>LA</th>
<th>KY</th>
<th>KS</th>
<th>IN</th>
<th>ID</th>
<th>HI</th>
<th>GU</th>
<th>GA</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>Biology</td>
<td>Biology</td>
<td>Biology- see other sci.</td>
<td>Biology</td>
<td>Biology</td>
<td>NA</td>
<td>Biology</td>
<td>Content</td>
</tr>
<tr>
<td>*</td>
<td>*</td>
<td>NA</td>
<td>*</td>
<td>NA</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>PPST</td>
</tr>
<tr>
<td>20235</td>
<td>20235</td>
<td>10235</td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td></td>
<td></td>
<td>Praxis II Bio</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Praxis II Bio/Gen Sci.</td>
</tr>
<tr>
<td>20231</td>
<td>20231</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Praxis II Bio. I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Praxis II Bio. II</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Praxis II Gen. Science content</td>
</tr>
<tr>
<td>30233</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Praxis II Essay</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pedagogy</td>
</tr>
<tr>
<td>30234 or 30483</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Principles/ Learning</td>
</tr>
<tr>
<td>30524</td>
<td>30524</td>
<td>30524</td>
<td>30524</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Other science related praxis II exam</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Comments</td>
</tr>
</tbody>
</table>

A Review of the University of Wisconsin- Superior Secondary Education Science Curriculum
<table>
<thead>
<tr>
<th>NH</th>
<th>NV</th>
<th>NE</th>
<th>MO</th>
<th>MS</th>
<th>MN</th>
<th>MD</th>
<th>ME</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>Biology</td>
<td>NA</td>
<td>Biology</td>
<td>Biology</td>
<td>Biology</td>
<td>Biology</td>
<td>NA</td>
<td>Content</td>
</tr>
<tr>
<td>*</td>
<td>*</td>
<td>NA</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>PPST</td>
<td></td>
</tr>
<tr>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>Praxis II Bio</td>
<td></td>
</tr>
<tr>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>Praxis II Bio. I</td>
<td></td>
</tr>
<tr>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>20231</td>
<td>Praxis II Bio. II</td>
<td></td>
</tr>
<tr>
<td>30233</td>
<td>30233</td>
<td>30233</td>
<td>30233</td>
<td>30233</td>
<td>30233</td>
<td>30233</td>
<td>Praxis II Gen. Science content</td>
<td></td>
</tr>
<tr>
<td>30234</td>
<td>30234</td>
<td>30234</td>
<td>30234</td>
<td>30234</td>
<td>30234</td>
<td>30234</td>
<td>Praxis II Essay</td>
<td></td>
</tr>
<tr>
<td>30524</td>
<td>30524 or 30524</td>
<td>30524</td>
<td>30524</td>
<td>30524</td>
<td>30524</td>
<td>30524</td>
<td>Principles/ Learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Other science related praxis II exam</td>
<td>Comments</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A Review of the University of Wisconsin Superior Secondary Education Science Curriculum
<p>| | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
<td>OK</td>
<td>OH 2</td>
<td>OH 1</td>
<td>ND</td>
<td>NC</td>
<td>NM</td>
<td>NJ</td>
<td>State</td>
</tr>
<tr>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>NA</td>
<td>PPST</td>
<td>Praxis II Bio</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Praxis II Bio/Gen Sci.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Praxis II Bio. I</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Praxis II Bio. II</td>
<td></td>
</tr>
<tr>
<td>20230</td>
<td>20235</td>
<td>20235</td>
<td>20236</td>
<td>PPST</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20232</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20232</td>
<td></td>
<td>Praxis II Gen. Science content</td>
<td></td>
</tr>
<tr>
<td>30233</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30234</td>
<td>Praxis II Essay</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pedagogy</td>
<td>Principles/ Learning</td>
</tr>
<tr>
<td>30524</td>
<td>30524</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Other science related praxis II exam</td>
<td>Comments</td>
</tr>
<tr>
<td>PPST only required if GPA is low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No testing required for teaching</td>
<td></td>
</tr>
<tr>
<td>UT</td>
<td>VI</td>
<td>TX</td>
<td>TN</td>
<td>SD</td>
<td>SC</td>
<td>RI</td>
<td>PA</td>
<td>State</td>
</tr>
<tr>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Biology</td>
<td>NA</td>
<td>NA</td>
<td>Biology</td>
<td>Biology</td>
<td>Biology</td>
<td>NA</td>
<td>Biology</td>
<td>Content</td>
</tr>
<tr>
<td>NA</td>
<td>*</td>
<td>NA</td>
<td>*</td>
<td>NA</td>
<td>*</td>
<td>*</td>
<td>PPST</td>
<td></td>
</tr>
<tr>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>20235</td>
<td>20230</td>
<td>20230</td>
<td>20230</td>
<td>Praxis II Bio</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20230</td>
<td>20230</td>
<td>20230</td>
<td>Praxis II Bio/ Gen Sci.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20230</td>
<td>20230</td>
<td>20230</td>
<td>Praxis II Bio. I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20230</td>
<td>20230</td>
<td>20230</td>
<td>Praxis II Bio. II</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20230</td>
<td>20230</td>
<td>20230</td>
<td>Praxis II Gen. Science content</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20230</td>
<td>20230</td>
<td>20230</td>
<td>Praxis II Essay</td>
</tr>
<tr>
<td>30234</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30234</td>
<td>Pedagogy</td>
</tr>
<tr>
<td>30524</td>
<td>30524</td>
<td>30524</td>
<td>30524</td>
<td>30524</td>
<td>30524</td>
<td>30524</td>
<td>30524</td>
<td>Principles/ Learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Requires testing other than Praxis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Comments</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------</td>
<td>------</td>
<td>---------------</td>
<td>-----------------</td>
<td>-----------------------------------</td>
<td>---------------------------------</td>
<td>----------</td>
<td>--------------------</td>
</tr>
<tr>
<td>VT</td>
<td>Biology</td>
<td>*</td>
<td>20231 or 30233</td>
<td>20435 or 30433</td>
<td>Praxis II Bio II Gen. Sci. content</td>
<td>Praxis II Bio II Gen. Sci. Essay</td>
<td>Pedagogy</td>
<td>Principles/ Learning</td>
</tr>
</tbody>
</table>

Comments: All science disciplines take Gen. Sci. Exam
The Praxis II for General Science Content is a broad field science test which addresses all areas of science. In Wisconsin, students educated to teach science in any of the science disciplines are required to be assessed with a broad field science exam. This exam is being used for determining the knowledge of future teachers from all the different course specific science curricula: biology, broad field science, chemistry, earth and space science, life and environmental science, physical science, and physics. The General Science Content Knowledge exam, number 10435, covers the following (Study, 2000):

I.) Scientific Methodology, Techniques, and History. 12 questions 10%

II.) The Physical Sciences (Both Physics and Chemistry). 48 questions 40%

III.) The Life Sciences (Including Ecology, Molecular and Cellular Biology, Plant and Animal Sciences, Genetics, and Evolution). 24 questions 20%

IV.) The Earth Sciences (Earth and Space science) 24 questions 20%

V.) Science, Technology, and Society (Philosophy, Laboratory Safety, History, and Basic Principles of Science). 12 questions 10%

Due to the change in the Department of Public Instruction (DPI) requirements and the need to pass the Praxis II exam, the University of Wisconsin-Superior must now reexamine its current secondary education degree requirements for the department of biology and determine if the present curriculum is adequate to prepare students for licensure. If voids are discovered regarding student preparation for the Praxis II test, they will need to be addressed.

While many of the questions on the Praxis II subject exams cover basic scientific concepts, “Some questions are of the advanced nature. These questions cover topics that Examinees will have studied in freshman college-level courses in physics, chemistry, life sciences, and earth sciences” (Study, 2002). The Praxis webpage gives a more detailed description of materials covered in each section of the General Content exam number 10435. They are as follows:
Scientific Methodology, Techniques, and History
will include: nature of scientific knowledge, inquiry, and historical perspectives; scientific methods and processes; facts, models, theories, and laws; historical roots of science and contributions made by major historical figures.

Mathematics, Measurements, Data Manipulation:
measurement and notation systems; data presentation and interpretation, error analysis is included.

Lab Procedures and Safety Techniques: including proper use, storage, and disposal of laboratory and field materials; selection and use of appropriate laboratory equipment.

Physical Science will include the following:
Matter and Energy: including structure, occurrence and abundance of elements, physical and chemical changes, forms and transformations of energy, conservation of mass and energy.
Heat and Thermodynamics: thermal energy, measurement, transfer and effects on matter; first and second laws of thermodynamics.
Atomic and Nuclear Structure: atomic and nuclear structure and related chemical properties; nuclear transformations and characteristics of radioisotopes and radiation.
Physics: Mechanics: straight-line, projectile, circular, and periodic motion; Newton’s laws of motion; work, energy, and power; simple machines; torque; friction; conservation of energy and momentum; gravity; Archimedes’ principle and Bernoulli’s principle.
Electricity and Magnetism: characteristics of static and current electricity, electrical circuits, alternating direct current, transformers, and motors; sources of EMF, magnetism.

Waves: characteristics of transverse and longitudinal waves; reflection, refraction, and interference; Doppler effects; sound; electromagnetic radiation; color; optics.

Chemistry: Periodicity: the periodic table; trends in chemical and physical properties.

The Mole and Chemical Bonding: the mole concept, the formulas and nomenclature of inorganic and organic compounds, bonding, electron dot and structural formulas, chemical composition and stoichiometry.

The Kinetic Theory and States of Matter: kinetic and molecular theory; phase characteristics and transformations, gas laws, characteristics of crystals.

Chemical reactions: types of reactions; endothermic and exothermic reactions; effects of temperature, pressure, concentration, and presence of catalysts on reactions; practical applications of electrochemistry; balance chemical equations.

Solutions and solubility: types of solutions; solvents and the dissolving process; effects of temperature and pressure on solubility; acids, bases, and salts; pH; buffers.

The Life Sciences include the following:
The Cell: biologically important inorganic and organic molecules, structure, and function of cells, cell organelles, cellular bioenergetics, the cell cycle, and cytokinesis, meiosis and mitosis, homeostasis.

Molecular Basis of Heredity and Classical Genetics: DNA replication, protein synthesis, Mendelian and non-Mendelian
inheritance, mutations and transposable elements, genetic engineering, human genetic disorders, recombinant DNA, mapping the human genome, the interaction between heredity and the environment.

Evolution: evidence, theories, and patterns of evolution; factors affecting evolution, speciation, and hypotheses relating to the origin of life.

Diversity of Life: general characteristics, biological systems of classification, viruses, bacteria, protists, fungi, plants, and animals.

Plants: structure and function of the roots, stems, and leaves; nonvascular plants; transport systems; control mechanisms; sexual and asexual reproduction.

Animals: anatomy and physiology of systems, homeostasis, response to stimuli.

Ecology: population dynamics, social behavior, interspecific relationships, community structure and species diversity, succession and disturbance, ecosystems, food webs and energy flow, biomes, biochemical cycles.

**Earth/Space Sciences** include the following:

Physical geology: minerals and rocks, folding and faulting, earthquakes and volcanoes, structure of Earth, plate tectonic theory and its supporting evidence, hydrologic cycle, weathering, erosional and depositional processes.

Historical Geology: uniformitarianism, time scales, fossils, and stratigraphy, Earth history.

Oceanography: waves, tides, and currents; ocean floor and margins; chemistry of seawater; shore processes; nutrient cycles of the ocean.

Meteorology: structure and properties of the atmosphere; seasonal and latitudinal
A Review of the University of Wisconsin-Superior Secondary Education Science Curriculum

variation of solar radiation; heat budgets; circulation patterns and winds; humidity, clouds, and precipitation; air masses, high and low pressure systems, frontal systems, maps and forecasting; climate and climate change.

Astronomy: theories of the origin and structure of the universe, origins and life cycles of stars, major features and structure of the solar system, Sun-Moon-Earth relationships, artificial satellites and space exploration, Earth’s seasons, time zones, large units of distance, contributions of remote sensing.

Science, Technology, and Society includes the following:
Impact of science and technology on the environment and human affairs.
Human and nature induced hazards.
Issues and applications: production and disposal of energy and consumer products, management of natural resources.
Social, political, ethical, and economic issues in science and technology.
Societal issues with health.

Graduating teacher candidates also need to be versed in their State Academic Model Standards. The Standards may differ slightly from state to state. These are the guides used by teachers in developing their core curriculum and lessons to ready their students for advancement through the grades levels. The State Standards establish what content knowledge is expected to be attained upon the completion of each grade level. According to the current Wisconsin state guidelines established by the DPI, students completing eighth and twelfth grades should have an understanding of the following (Wisconsin DPI, 2004):

Content Standard A. Science Connections: Students in Wisconsin will understand that there are unifying themes: systems, order, organization, and interactions; evidence, models, and explanations; constancy, change, and measurement; evolution, equilibrium, and energy; form and function among scientific disciplines.
Content Standard B. Nature of Science: Students in Wisconsin will understand that science is ongoing and inventive, and that scientific understandings have changed over time as new evidence is found.

Content Standard C. Science Inquiry: Students in Wisconsin will investigate questions using scientific methods and tools, revise their personal understanding to accommodate knowledge, and communicate these understandings to others.

Content Standard D. Physical Science: Students in Wisconsin will demonstrate an understanding of the physical and chemical properties of matter, the forms and properties of energy, and the ways in which matter and energy interact.

Content Standard E. Earth and Space Science: Students in Wisconsin will demonstrate an understanding of the structure and systems of earth and other bodies in the universe and of their interactions.

Content Standard F. Life and Environmental Science: Students in Wisconsin will demonstrate an understanding of the characteristics and structures of living things, the processes of life, and how living things interact with one another and their environment.

Content Standard G. Science Applications: Students in Wisconsin will demonstrate an understanding of the relationship between science and technology and the ways in which that relationship influences human activities.

Content Standard H. Science in Personal and Social Perspectives: Students in Wisconsin will use scientific information and skills to make decisions about themselves, Wisconsin, and the world in which they live.
The State Academic Standards in Minnesota are slightly different from those of Wisconsin, but both are derived from the Federal Academic Standards; deviation should be minimal. The Minnesota Academic Standards for grades eighth through twelve can be found in Appendix II.

The new changes brought about by PI 34 require that science teachers must be prepared to teach all of the above science content. The UW–Superior teacher’s education handbook notes that change to their curricula was mandated November 19, 2004. A memorandum sent by Peter Burke, Director of Teacher Education, Professional development, and Licensing, dated July 29, 2002, was sent to all the Deans, Chairs, and Directors of Education Programs and is quoted in the handbook (p. 57). It clarifies the interpretation of the science license section of PI 34. The Administrative rule, PI 34.29 (2) states:

(c.) Science.

1. In order to qualify for a license under this paragraph, an individual shall have completed a science program major in one of the subcategories under this subdivision. The science program shall include competencies in each of the subcategories listed under this subdivision with a concentration in at least one of the subcategories. A concentration is required to teach upper level high school courses in the specific subject subcategories. The following subcategories are available as individual licenses and shall be included in the broad field science license:
   a. Physical Science, which includes chemistry and Physics.
   b. Earth and space science.
   c. Life and environmental science, which includes biology and environmental studies.

As stated in the Secondary Education Handbook:
In order to be licensed under this paragraph [PI 34.29], an individual shall complete a program that incorporates the Wisconsin Model Academic Standards for science, including all of the following strands:
   a. Science connections.
   b. Nature of science.
   c. Science inquiry.
   d. Physical science
   e. Earth and space science.
   f. Life and environmental science.
   g. Science applications.
   h. Science in personal and social perspectives.
Due to these new mandates, the question has been raised regarding whether or not biology majors going into secondary education ought to be required to take physics, geology, and a science and technology course in order to better prepare them to be able to teach the curriculum that is required by the State Academic Model Standards and to excel at the Praxis II exam.

This study reviewed current curricula and identified areas that may be deficient in preparing the students for success with the currently used assessment. The goal of science preparation is not only to pass the exams but also to ensure that the graduating science teachers are well versed in their major and prepared to teach the required curriculum that meets the present Wisconsin State Academic Model Standards. Students would also be better equipped to excel at the Praxis II exam with an educational background that is more diversified. The curricula of the Universities of Wisconsin-Superior (UW-Superior), University of Wisconsin-Madison (UW-Madison), University of Minnesota-Duluth (UMD), and The College of St. Scholastica (CSS) will be compared for possible adaptations that can be incorporated into the existing teacher development plan at UW-Superior.

**Methods**

College catalogs from The College of Saint Scholastica (CSS), University of Minnesota-Duluth (UMD), University of Wisconsin-Madison (UW-Madison), and University of Wisconsin-Superior (UW-Superior) were compared regarding their Teacher Education Programs for secondary education in the field of biology. These colleges either have a reputation for excellence in teacher training or are in the area in direct competition with UW-Superior for incoming students in this field. UW-Superior wants to be able to offer the best teacher preparation program for science in the area thus increasing future enrollment and the output of excellent future science educators. The Praxis II exam was scrutinized for the percent of material from each science discipline represented on the test versus the required educational level of our graduating teacher education seniors of Biology. The study also compared the courses currently offered or required to the material covered by the examinations. The Wisconsin Model Academic Standards from the DPI were also examined to assure the graduates are able to teach science at a secondary educational level.

**Discussion**

The Praxis II and the Wisconsin Model Academic Standards address nearly all the same content (Table II). The following table lists the colleges and their required Biology Secondary Education curricula for
comparison to the Praxis II: General Science Content Knowledge exam-10435 and the Wisconsin Model Academics Standards content.

Table II. Comparison of Biology Secondary Education Curriculum Requirements, Praxis II, and Wisconsin State Model Academics

<table>
<thead>
<tr>
<th></th>
<th>Praxis II exam 10435</th>
<th>UWL State Model Academics</th>
<th>UW-Superior</th>
<th>UW-Madison</th>
<th>UW-Milwaukee</th>
<th>UW-Duluth</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Biology I &amp; II</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Human Anatomy</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Ecology</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Cell Biology</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Genetics</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Evolution - Upper Level</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Environmental Science</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Physiological / Organismal Biology</td>
<td>* see discussion</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Population Biology</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Systematics</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Capstone Research</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Chemistry I &amp; II</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Physics I &amp; II</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Physical Science</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Geology</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Geomorphology Upper Level</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Advanced Earth Science for Teachers</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Meteorology</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Astronomy</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Science, Technology, &amp; Society (History)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>
The subjects covered by both the Wisconsin Model Academics Standards and the Praxis II exam are general biology, zoology, botany, physics, chemistry, earth sciences, astronomy, environmental science, evolution, physical science, cell biology, ecology, genetics, and geology. They differ
in that Wisconsin Model Academic Standards do not specifically address human anatomy, laboratory safety, and geomorphology whereas the Praxis II does not have any questions regarding computer technology skills, although it does test regarding science-related technology and techniques.

The UW-Superior required courses for biology majors both fulfill the Teachers Education requirements and give the graduating senior an actual biology degree which can be used in other job-related avenues. The curriculum has a base list of classes which it requires all the biology majors to take and which consist of general biology I and II, genetics, ecology, and cell biology. Chemistry I and II are prerequisites for some of the core curriculum. The rest of the required classes are electives which must be taken under the category headings of population biology, physiology/organismal biology, and systematic courses. Students must choose a class from each of the sections and Secondary Education students must take additional animal and plant science courses. The same course can fulfill a category requirement while fulfilling the Plant/Animal science requirement. The plant and animal science classes are marked with a (A) or (P) following the name. The classes under each heading are as follows (University of Wisconsin-Superior, 2004):

Population Biology courses:
- General Forestry
- Marine Biology
- Evolution
- Biogeography
- Limnology
- Animal Behavior (A)
- Fish Population Ecology

Physiological/Organismal Biological courses:
- Human Anatomy and Physiology
- Plant Morphology (P)
- Plant Physiology (P)
- Animal Physiology (A)
- Neurobiology

Systematic courses:
- Phycology and Mycology (P)
- Plant Taxonomy (P)
- Aquatic Entomology (A)
- General Microbiology
- Parasitology (A)
- Entomology (A)
A Review of the University of Wisconsin-Superior Secondary Education Science Curriculum

Ornithology (A)  
Vertebrate Biology (A)  
Ichthology (A)  

For example, the student can elect to take evolution, either plant morphology or plant physiology and animal physiology which would fulfill their class requirements, would help to ready them to teach to the Model Academics, and would help prepare the student to take the Praxis II test (Table II). Physics, physical science, geology, astronomy, earth sciences, and meteorology are currently not required classes for biology majors, which leaves a large portion of the body of the Wisconsin Model Academics Standards and Praxis II unaddressed. It is currently up to the academic advisor to instruct the student regarding those classes which will best ready him/her for a professional goal.

UW-Madison has discipline related course requirements rather than specific course requirements. These requirements include a minimum of six credits of college level mathematics and/or statistics, general chemistry I and II, and general physics I and II. Students have two biology major options from which to select. Within Option A the students can choose between two different sets of accompanying classes to go with the introductory biology class that is required. The first set is for students with an interest in animal sciences. It consists of an introductory biology course and zoology I and II with lab as well as botany. The other option is a mix of two classes of zoology/botany and an introductory biology. For either of these groups of courses, general genetics is required. Students are required to take one upper level elective course (listed below) from each of the following categories. Each elective course can fulfill one category requirement. The number of different classes available for students to consider for selection under each subcategory is listed below (University of Wisconsin-Madison, 2005):

**Ecology, Evolution, Genetics courses:**
- Botany: 15 courses  
- Zoology: 22 courses.  
- Bacteriology: 1 course.  
- Entomology: 6 courses.  
- Genetics: 7 courses.  
- Horticulture: 2 courses.  
- Landscape Architecture: 3 courses.  
- Plant Pathology: 1 course.

**Cell and Molecular Biology courses:**
- Bacteriology: 5 courses.
Botany: 4 courses.
Genetics: 2 courses.
Zoology: 4 courses.

**Physiology courses:**
Botany: 2 courses.
Zoology: 4 courses.
Physiology: 1 course.

Major Option B is a four semester program called the Biology Core Curriculum (also known as the Biocore program). The program is an “interdepartmental course sequence providing undergraduates with an integrated approach to biology and a broad background for subsequent specialization in a biological oriented field of study. Completion of this sequence requires more course work than Option A (University of Wisconsin-Madison, 2005).” Option B’s Biocore program begins during the freshman’s first two semesters with students taking chemistry and math along with their general course work. During their sophomore year, not only do the students take chemistry and calculus but they also take Biocore 301-evolution, ecology, and genetics accompanied by lab, number 302, their first semester; Biocore 303-cell biology and lab-304, the second. Juniors finish the Biocore curriculum taking Biocore 323-organismal biology and lab-324 along with physics and biochemistry. The second semester finishes with Biocore 333-biological interactions, physics, and biochemistry 508 (UW–Madison, 2005).

Both Option A and B are primarily Biology majors that have included general physics, and general chemistry; whereas neither addresses physical science, earth science, astronomy, or geology, which are fundamental to both The State Model Academics and the Praxis II exam (Table II).

The University of Minnesota-Duluth (UMD) offers secondary educations degrees in Biology as well as all the different disciplines of science, but UMD has developed specific curricula for Science Secondary Education majors. “This major is designed to prepare students to teach all science areas in grades 5 through 8 and to teach Life Science in grades 9 through 12 (University of Minnesota-Duluth, 2003).” The courses listed within UMD Science Secondary Education Program fulfill all the information covered within the Wisconsin Model Academics Standards and the Praxis II exam except a course in physical science, and environmental science (Table II). UMD requires 59 lower division credits and 54 upper division credits for the B.A.S. degree in teaching Life Science. Students have the option of also completing the Environmental Education Concentration with this major (University of Minnesota-Duluth, 2003).
The Lower Division classes are as follows:
(59 credits total)
- Introductory to Astronomy
- General Biology I and II
- Human Anatomy
- Cell Biology
- Genetics
- General Ecology Lecture and Lab
- Intro to General, Organic, and Biological Chemistry I and II
- Education in Modern Society
- Geology and Earth Systems
- Precalculus Analysis
- Introduction to Physics I and II

The Upper Division classes are as follows:
(54 credits total)
- Evolution
- The Computer in Education
- Science, Technology, and Society
- Geomorphology or Earth History or The Earth’s Dynamic Interior
- Advanced Earth Science for Teachers
- Teaching Science: Grades 5-12
- General Physiology or Physiology of Organ Systems
- Drug Education
- Nine General Teaching Courses which includes a semester (12 credits) of student teaching equaling 31 credits total.

Although it is not a true biology major, UMD’s Secondary Education degree offers a rich variety of classes for the Life Science Teacher Program. It is far more varied in course work than the UW-Superior Broad Field Science major. The Broad Field Science major at UW-Superior requires one year of each general biology, general chemistry, general physics, and geology as well as a history and Philosophy of Science course. Students at UW–Superior can fulfill the 54 credit requirement by taking six more credits in two of the four areas.

While the Life Science Teacher Program at UMD lacks a specific plant or animal component, it integrates topics in general biology. It also has an extensive writing requirement. It demands a writing course to be taken in either Advanced Writing: Science, or Advance Writing: Human Services. The curriculum is a diversified science program offering education in nearly all the major scientific fields as well as in pre-calculus, computer, and technology. It exposes students to a wide array of classes.
and course content without requiring higher levels of most coursework. The majority of classes are introductory level. Students can take an optional environmental education concentration with which they could take a plant or an animal science class (University of Minnesota-Duluth, 2003). This course work is more than adequate to prepare the future educators to be able to teach the Wisconsin Model Academic Standards and to take the required Wisconsin Praxis II assessment (Table II).

The College of St. Scholastica requires Biology majors for those students who plan on teaching Biology Secondary Education. The course work for a student’s major is clearly mapped out with the necessary teacher’s education courses added. The class work is broken down into expectations at each grade level. During the freshman year, students are expected to take one semester each of each plant and animal biology as well as a year of general chemistry. They will also take an introductory course for teacher’s education and general education classes. Sophomore students take a year of anatomy/physiology I and II, and physics I and II. Additional teacher preparation classes are taken as well as general education classes. In the junior year, students complete ecology, genetics, science methods, science and culture, and some additional teacher’s education classes. During the senior year, students take cosmic systems and finish any uncompleted general education courses. The last semester is scheduled for the undergraduate to student teach. Before graduation, the biology students do have to complete one additional plant biology course and four additional credits in an elective biology course. It is recommended that the students choose from microbiology, embryology or plant systematics to fulfill this requirement (College of St. Scholastica, n.d.). The overall curriculum lacks environmental science, evolution, geology, astronomy, meteorology, physical science and earth science (Table II). In comparing the curriculum of the College of St. Scholastica to the required knowledge needed for succeeding at the Praxis II examination and for being able to teach the State Model Academic Standards used in Wisconsin, the students of biology secondary education are not being fully prepared.

**Conclusion**

The State Model Academic Standards are tools used by the instructors in our elementary and secondary educational facilities to assure students will receive a well rounded education. They are not meant to be taught solely in one discipline, but rather in conjunction with all the different areas of science secondary education. It is up to the future teachers to know the expectations of the DPI for establishing their curriculum and for preparing their students, but it is not the burden of only the biology instructor, or the chemistry instructor, or the physics instructor
to make sure the students know all the different disciplines of science; it is the whole educating team’s duty to work together to make certain academic standards are met. From the moment a child steps foot in a school it becomes our, the educators, responsibility and obligation to assure the students are given every means possible to succeed.

The current biology major curriculum at UW-Superior contains a complete selection of classes for a person entering a biological career or the research field, however it does not fully prepare the biology secondary education students for the requirements established for them by the Wisconsin State Model Academics. The Praxis II exam required by Wisconsin is broad field in nature and students earning biology majors UW-Superior at are not currently required to be educated in the topics covered by certain disciplines, such as geology, earth science, or physics. All the colleges examined, except UW-Superior, have a year of physics as a requirement for biology and life science Secondary Education majors.

The College of St. Scholastica does require also a year of anatomy/physiology, and a semester of cosmic systems. Their biology major currently is lacking necessary course work to equip students to teach to the Wisconsin Model Academic Standards and to excel on the Wisconsin state required Praxis II testing by graduating candidates.

University of Wisconsin-Madison has an extensive number of classes from which a biology student can choose. They do require physics, as well as higher levels of plant and animal sciences. But UW-Madison, much like UW-Superior, currently does not address physical science, earth science, astronomy, or geology as core curriculum.

The curriculum from the University of Minnesota-Duluth is the most complete of all the colleges considered. They teach nearly all disciplines of science to the students of the Life Science Program. If a candidate chose to complete the environmental science concentration offered, they would have a very complete educational background for meeting the requirements of the Wisconsin Model State Academics, for passing the Praxis II-Science General Content Exam: 10435 required by Wisconsin, and for teaching life science at a secondary level.

Based on this review, it appears UW–Superior needs to analyze its current curriculum to see if adjustments can be made to better prepare the graduating secondary education biology candidates for teaching to the Wisconsin Model Academic Standards, excelling on the Praxis II, and becoming well rounded, exceptional teachers.
Appendix I

Wisconsin Model Academic Standards

Science, Standard A: Science Connections Performance Standards-Grade 8

By the end of grade eight, students will:

A.8.1 Develop their understanding of the science themes by using the themes to frame questions about science-related issues and problems.

A.8.2 Describe limitations of science systems and give reasons why specific science themes are included in or excluded from those systems.

A.8.3 Defend explanations and models by collecting and organizing evidence that supports them and critique explanations and models by collecting and organizing evidence that conflicts with them.

A.8.4 Collect evidence to show that models developed as explanations for events were (and are) based on the evidence available to scientists at the time.

A.8.5 Show how models and explanations, based on systems, were changed as new evidence accumulated (the effects of constancy, evolution, change, and measurement should all be part of these explanations).

A.8.6 Use models and explanations to predict actions and events in the natural world.

A.8.7 Design real or thought investigations to test the usefulness and limitations of a model.

A.8.8 Use the themes of evolution, equilibrium, and energy to predict future events or changes in the natural world.

Science, Standard A: Science Connections Performance Standards Grade 12
By the end of grade twelve, students will:

A.12.1 Apply the underlying themes of science to develop defensible visions of the future.

A.12.2 Show how conflicting assumptions about science themes lead to different opinions and decisions about evolution, health, population, longevity, education, and use of resources, and show how these opinions and decisions have diverse effects on an individual, a community, and a country, both now and in the future.

A.12.3 Give examples that show how partial systems, models, and explanations are used to give quick and reasonable solutions that are accurate enough for basic needs.

A.12.4 Construct arguments that show how conflicting models and explanations of events can start with similar evidence.

A.12.5 Show how the ideas and themes of science can be used to make real-life decisions about careers, work places, life-styles, and use of resources.

A.12.6 Identify and, using evidence learned or discovered, replace inaccurate personal models and explanations of science-related events.

A.12.7 Re-examine the evidence and reasoning that led to conclusions drawn from investigations, using the science themes.

Science, Standard B: Nature of Science Performance Standards - Grade 8

By the end of grade eight, students will:

B.8.1 Describe how scientific knowledge and concepts have changed over time in the earth and space, life and environmental, and physical sciences.

B.8.2 Identify and describe major changes that have occurred over in conceptual models and explanations in the earth and space, life and environmental, and physical sciences and identify the people, cultures, and conditions that led to these developments.
B.8.3 Explain how the general rules of science apply to the development and use of evidence in science investigations, model-making, and applications.

B.8.4 Describe types of reasoning and evidence used outside of science to draw conclusions about the natural world.

B.8.5 Explain ways in which science knowledge is shared, checked, and extended, and show how these processes change over time.

B.8.6 Explain the ways in which scientific knowledge is useful and also limited when applied to social issues

Science, Standard B: Nature of Science Performance Standards - Grade 12

By the end of grade twelve, students will:

B.12.1 Show how cultures and individuals have contributed to the development of major ideas in the earth and space, life and environmental, and physical sciences.

B.12.2 Identify the cultural conditions that are usually present during great periods of discovery, scientific development, and invention.

B.12.3 Relate the major themes of science to human progress in understanding science and the world.

B.12.4 Show how basic research and applied research contribute to new discoveries, inventions, and applications.

B.12.5 Explain how science is based on assumptions about the natural world and themes that describe the natural world.

Science, Standard C: Science Inquiry Performance Standards - Grade 8

By the end of grade eight, students will:

C.8.1 Identify questions they can investigate using resources and equipment they have available.
C.8.2 Identify data and locate sources of information including their own records to answer the questions being investigated.

C.8.3 Design and safely conduct investigations that provide reliable quantitative or qualitative data, as appropriate, to answer their questions.

C.8.4 Use inferences to help decide possible results of their investigations, use observations to check their inferences

C.8.5 Use accepted scientific knowledge, models, and theories to explain their results and to raise further questions about their investigations.

C.8.6 State what they have learned from investigations, relating their inferences to scientific knowledge and to data they have collected.

C.8.7 Explain their data and conclusions in ways that allow an audience to understand the questions they selected for investigation and the answers they have developed.

C.8.8 Use computer software and other technologies to organize, process, and present their data.

C.8.9 Evaluate, explain, and defend the validity of questions, hypotheses, and conclusions to their investigations.

C.8.10 Discuss the importance of their results and implications of their work with peers, teachers, and other adults.

C.8.11 Raise further questions which still need to be answered

Science, Standard C: Science Inquiry Performance Standards - Grade 12

By the end of grade twelve, students will:

C.12.1 When studying science content, ask questions suggested by current social issues, scientific literature, and observations of phenomena, build hypotheses that might answer some of these questions, design possible investigations, and describe results that might emerge from such investigations
C.12.2 Identify issues from an area of science study, write questions that could be investigated, review previous research on these questions, and design and conduct responsible and safe investigations to help answer the questions.

C.12.3 Evaluate the data collected during an investigation, critique the data-collection procedures and results, and suggest ways to make any needed improvements.

C.12.4 During investigations, choose the best data-collection procedures and materials available, use them competently, and calculate the degree of precision of the resulting data.

C.12.5 Use the explanations and models found in the earth and space, life and environmental, and physical sciences to develop likely explanations for the results of their investigations.

C.12.6 Present the results of investigations to groups concerned with the issues, explaining the meaning and implications of the results, and answering questions in terms the audience can understand.

C.12.7 Evaluate articles and reports in the popular press, in scientific journals, on television, and on the Internet, using criteria related to accuracy, degree of error, sampling, treatment of data, and other standards of experimental design.

Science, Standard D: Physical Science Performance Standards - Grade 8

By the end of grade eight, students will:

PROPERTIES AND CHANGES OF PROPERTIES IN MATTER

D.8.1 Observe, describe, and measure physical and chemical properties of elements and other substances to identify and group them according to properties such as density, melting points, boiling points, conductivity, magnetic attraction, solubility, and reactions to common physical and chemical tests.

D.8.2 Use the major ideas of atomic theory and molecular theory to describe physical and chemical interactions among substances, including solids, liquids, and gases.
D.8.3 Understand how chemical interactions and behaviors lead to new substances with different properties.

D.8.4 While conducting investigations, use the science themes to develop explanations of physical and chemical interactions and energy exchanges.

MOTIONS AND FORCES

D.8.5 While conducting investigations, explain the motion of objects by describing the forces acting on them.

D.8.6 While conducting investigations, explain the motion of objects using concepts of speed, velocity, acceleration, friction, momentum, and changes over time, among others, and apply these concepts and explanations to real-life situations outside the classroom.

D.8.7 While conducting investigations of common physical and chemical interactions occurring in the laboratory and the outside world, use commonly accepted definitions of energy and the idea of energy conservation.

TRANSFER OF ENERGY

D.8.8 Describe and investigate the properties of light, heat, gravity, radio waves, magnetic fields, electrical fields, and sound waves as they interact with material objects in common situations.

D.8.9 Explain the behaviors of various forms of energy by using the models of energy transmission, both in the laboratory and in real-life situations in the outside world.

D.8.10 Explain how models of the atomic structure of matter have changed over time, including historical models and modern atomic theory.

Science, Standard D: Physical Science Performance Standards - Grade 12

By the end of grade twelve, students will:
STRUCTURE OF ATOMS AND MATTER

D.12.1 Describe atomic structure and the properties of atoms, molecules, and matter during physical and chemical interactions.

D12.2 Explain the forces that hold the atom together and illustrate how nuclear interactions change the atom.

D.12.3 Explain exchanges of energy in chemical interactions and exchange of mass and energy in atomic/nuclear reactions.

CHEMICAL REACTIONS

D.12.4 Explain how substances, both simple and complex, interact with one another to produce new substances.

D.12.5 Identify patterns in chemical and physical properties and use them to predict likely chemical and physical changes and interactions.

D.12.6 Through investigations, identify the types of chemical interactions, including endothermic, exothermic, oxidation, photosynthesis, and acid/base reactions.

MOTIONS AND FORCES

D.12.7 Qualitatively and quantitatively analyze changes in the motion of objects and the forces that act on them and represent analytical data both algebraically and graphically.

D.12.8 Understand the forces of gravitation, the electromagnetic force, intermolecular force, and explain their impact on the universal system.

D.12.9 Describe models of light, heat, and sound and through investigations describe similarities and differences in the way these energy forms behave.

CONSERVATION OF ENERGY AND THE INCREASE IN DISORDER

D.12.10 Using the science themes, illustrate the law of conservation of energy during chemical and nuclear reactions.
A Review of the University of Wisconsin-Superior Secondary Education Science Curriculum

INTERACTIONS OF MATTER AND ENERGY

D.12.11 Using the science themes, explain common occurrences in the physical world.

D.12.12 Using the science themes and knowledge of chemical, physical, atomic, and nuclear interactions, explain changes in materials, living things, earth's features, and stars.

Science, Standard E: Earth and Space Science Performance Standards - Grade 8

By the end of grade eight, students will:

STRUCTURE OF EARTH SYSTEM

E.8.1 Using the science themes explain and predict changes in major features of land, water, and atmospheric systems.

E.8.2 Describe underlying structures of the earth that cause changes in the earth's surface.

E.8.3 Using the science themes during the process of investigation, describe climate, weather, ocean currents, soil movements and changes in the forces acting on the earth.

E.8.4 Using the science themes, analyze the influence living organisms have had on the earth's systems, including their impact on the composition of the atmosphere and the weathering of rocks.

EARTH'S HISTORY

E.8.5 Analyze the geologic and life history of the earth, including change over time, using various forms of scientific evidence.

E.8.6 Describe through investigations the use of the earth's resources by humans in both past and current cultures, particularly how changes in the resources used for the past 100 years are the basis for efforts to conserve and recycle renewable and non-renewable resources.
EARTH IN THE SOLAR SYSTEM

E.8.7 Describe the general structure of the solar system, galaxies, and the universe, explaining the nature of the evidence used to develop current models of the universe.

E.8.8 Using past and current models of the structure of the solar system, explain the daily, monthly, yearly, and long-term cycles of the earth, citing evidence gained from personal observation as well as evidence used by scientists.

Science, Standard E: Earth and Space Science Performance Standards - Grade 12

By the end of grade twelve, students will:

ENERGY IN THE EARTH SYSTEM

E.12.1 Using the science themes, distinguish between internal energies (decay of radioactive isotopes, gravity) and external energies (sun) in the earth's systems and show how these sources of energy have an impact on those systems.

GEOCHEMICAL CYCLES

E.12.2 Analyze the geochemical and physical cycles of the earth and use them to describe movements of matter

THE ORIGIN AND EVOLUTION OF THE EARTH SYSTEM

E.12.3 Using the science themes, describe theories of the origins and evolution of the universe and solar system, including the earth system as a part of the solar system, and relate these theories and their implications to geologic time on earth.

E.12.4 Analyze the benefits, costs, and limitations of past, present, and projected use of resources and technology and explain the consequences to the environment.
THE ORIGIN AND EVOLUTION OF THE UNIVERSE

E.12.5 Using the science themes, understand that the origin of the universe is not completely understood, but that there are current ideas in science that attempt to explain its origin.

Science, Standard F: Life and Environmental Science Performance Standards - Grade 8

By the end of grade eight, students will:

STRUCTURE AND FUNCTION IN LIVING THINGS

F.8.1 Understand the structure and function of cells, organs, tissues, organ systems, and whole organisms.

F.8.2 Show how organisms have adapted structures to match their functions, providing means of encouraging individual and group survival within specific environments.

F.8.3 Differentiate between single-celled and multiple-celled organisms (humans) through investigation, comparing the cell functions of specialized cells for each type of organism.

REPRODUCTION AND HEREDITY

F.8.4 Investigate and explain that heredity is comprised of the characteristic traits found in genes within the cell of an organism.

F.8.5 Show how different structures both reproduce and pass on characteristics of their group.

REGULATION AND BEHAVIOR

F.8.6 Understand that an organism is regulated both internally and externally.

F.8.7 Understand that an organism's behavior evolves through adaptation to its environment.
POPULATIONS AND ECOSYSTEMS

F.8.8 Show through investigations how organisms both depend on and contribute to the balance or imbalance of populations and/or ecosystems, which in turn contribute to the total system of life on the planet.

DIVERSITY AND ADAPTATIONS OF ORGANISMS

F.8.9 Explain how some of the changes on the earth are contributing to changes in the balance of life and affecting the survival or population growth of certain species.

F.8.10 Project how current trends in human resource use and population growth will influence the natural environment, and show how current policies affect those trends.

Science, Standard F: Life and Environmental Science Performance Standards - Grade 12

By the end of grade twelve, students will:

THE CELL

F.12.1 Evaluate the normal structures and the general and special functions of cells in single-celled and multiple-celled organisms.

F.12.2 Understand how cells differentiate and how cells are regulated.

THE MOLECULAR BASIS OF HEREDITY

F.12.3 Explain current scientific ideas and information about the molecular and genetic basis of heredity.

F.12.4 State the relationships between functions of the cell and functions of the organism as related to genetics and heredity.
BIOLOGICAL EVOLUTION

F.12.5 Understand the theory of evolution, natural selection, and biological classification.

F.12.6 Using concepts of evolution and heredity, account for changes in species and the diversity of species, include the influence of these changes on science, e.g. breeding of plants or animals.

THE INTERDEPENDENCE OF ORGANISMS

F.12.7 Investigate how organisms both cooperate and compete in ecosystems.

F.12.8 Using the science themes, infer changes in ecosystems prompted by the introduction of new species, environmental conditions, chemicals, and air, water, or earth pollution.

MATTER, ENERGY AND ORGANIZATION IN LIVING SYSTEMS

F.12.9 Using the science themes, investigate energy systems (related to food chains) to show how energy is stored in food (plants and animals) and how energy is released by digestion and metabolism.

F.12.10 Understand the impact of energy on organisms in living systems.

F.12.11 Investigate how the complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain an organism.

THE BEHAVIOR OF ORGANISMS

F.12.12 Trace how the sensory and nervous systems of various organisms react to the internal and external environment and transmit survival or learning stimuli to cause changes in behavior or responses.

Science, Standard G: Science Applications Performance Standards Grade 8

By the end of grade eight, students will:
G.8.1 Identify and investigate the skills people need for a career in science or technology and identify the academic courses that a person pursuing such a career would need.

G.8.2 Explain how current scientific and technological discoveries have an influence on the work people do and how some of these discoveries also lead to new careers.

G.8.3 Illustrate the impact that science and technology have had, both good and bad, on careers, systems, society, environment, and quality of life.

G.8.4 Propose a design (or re-design) of an applied science model or a machine that will have an impact in the community or elsewhere in the world and show how the design (or re-design) might work, including potential side-effects.

G.8.5 Investigate a specific local problem to which there has been a scientific or technological solution, including proposals for alternative courses of action, the choices that were made, reasons for the choices, any new problems created, and subsequent community satisfaction.

G.8.6 Use current texts, encyclopedias, source books, computers, experts, the popular press, or other relevant sources to identify examples of how scientific discoveries have resulted in new technology.

G.8.7 Show evidence of how science and technology are interdependent, using some examples drawn from personally conducted investigations.

Science, Standard G: Science Applications Performance Standards Grade 12

By the end of grade twelve, students will:

G.12.1 Identify personal interests in science and technology, implications that these interests might have for future education, and decisions to be considered.

G.12.2 Design, build, evaluate, and revise models and explanations related to the earth and space, life and environmental, and physical sciences.
G.12.3 Analyze the costs, benefits, or problems resulting from a scientific or technological innovation, including implications for the individual and the community.

G.12.4 Show how a major scientific or technological change has had an impact on work, leisure, or the home.

G.12.5 Choose a specific problem in our society, identify alternative scientific or technological solutions to that problem and argue it merits.

Science, Standard H: Science in Personal and Social Perspectives
Performance Standards - Grade 8

By the end of grade eight, students will:

H.8.1 Evaluate the scientific evidence used in various media (for example, television, radio, Internet, popular press, and scientific journals) to address a social issue, using criteria of accuracy, logic, bias, relevance of data, and credibility of sources.

H.8.2 Present a scientific solution to a problem involving the earth and space, life and environmental, or physical sciences and participate in a consensus-building discussion to arrive at a group decision.

H.8.3 Understand the consequences of decisions affecting personal health and safety.

Science, Standard H: Science in Personal and Social Perspectives
Performance Standards - Grade 12

By the end of grade twelve, students will:

H.12.1 Using the science themes and knowledge of the earth and space, life and environmental, and physical sciences, analyze the costs, risks, benefits, and consequences of a proposal concerning resource management in the community and determine the potential impact of the proposal on life in the community and the region.

H.12.2 Evaluate proposed policy recommendations (local, state, and/or national) in science and technology for validity, evidence, reasoning, and implications, both short and long-term.
H.12.3 Show how policy decisions in science depend on social values, ethics, beliefs, and time-frames as well as considerations of science and technology.

H.12.4 Advocate a solution or combination of solutions to a problem in science or technology.

H.12.5 Investigate how current plans or proposals concerning resource management, scientific knowledge, or technological development will have an impact on the environment, ecology, and quality of life in a community or region.

H.12.6 Evaluate data and sources of information when using scientific information to make decisions.

H.12.7 When making decisions, construct a plan that includes the use of current scientific knowledge and scientific reasoning.

Wisconsin Department of Public Instruction.
Wisconsin Model Academic Standards.
March 30, 2005.
## Appendix II
### Minnesota Academic Standards
#### 8-12

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Strand</th>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
</table>
| GRADE 8     | I. HISTORY AND NATURE OF SCIENCE | A. Scientific World View | The student will understand that science is a way of knowing about the world that is characterized by empirical criteria, logical argument and skeptical review. | 1. The student will explain and give examples of how science can be used to make informed ethical decisions by identifying likely consequences of particular actions.  
2. The student will explain the development, usefulness and limitations of scientific models in the explanation and prediction of natural phenomena. |
| GRADE 8     | I. HISTORY AND NATURE OF SCIENCE | B. Scientific Inquiry | The student will understand that scientific inquiry is used by scientists to investigate the natural world in systematic ways. | 1. The student will know that scientific investigations involve the common elements of systematic observations, the careful collection of relevant evidence, logical reasoning and innovation in developing hypotheses and explanations.  
2. The student will describe how scientists can conduct investigations in a simple system and make generalizations to more complex systems. |
| GRADE 8     | I. HISTORY AND NATURE OF SCIENCE | B. Scientific Inquiry | The student will use multiple skills to design and conduct scientific investigations. | 1. The student will specify variables to be changed, controlled and measured.  
2. The student will use sufficient trials and adequate sample size to ensure reliable data.  
3. The student will use appropriate technology and mathematics skills to access, gather, store, retrieve and organize data. |
### Grade Level: GRADE 8

#### Strand: I. HISTORY AND NATURE OF SCIENCE

<table>
<thead>
<tr>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. Scientific Enterprise</td>
<td>The student will know that science and technology are human efforts that both influence and are influenced by civilizations and cultures worldwide.</td>
<td>1. The student will evaluate the credibility and validity of scientific and technological information from various sources.</td>
</tr>
</tbody>
</table>

#### Strand: D. Historic Perspectives

<table>
<thead>
<tr>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
</table>
| D. Historic Perspectives                                                 | The student will understand how scientific discovery, culture, societal norms and technology have influenced one another in different time periods. | 1. The student will relate personal experiences in scientific investigation to the experiences of scientists throughout history.  
2. The student will cite examples of how science and technology contributed to changes in agriculture, manufacturing, sanitation, medicine, warfare, transportation, information processing or communication.|
<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Strand</th>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRADE 8</td>
<td>III. EARTH AND SPACE SCIENCE</td>
<td>A. Earth Structure and Processes</td>
<td>The student will identify Earth’s composition, structure and processes.</td>
<td>1. The student will explain how earthquakes, volcanoes, sea-floor spreading and mountain building are evidence of the movement of crustal plates.  2. The student will describe how features on the Earth’s surface are created and constantly changing through a combination of slow and rapid processes of weathering, erosion, sediment deposition, landslides, volcanic eruptions and earthquakes.  3. The student will describe the various processes and interactions of the rock cycle.  4. The student will interpret successive layers of sedimentary rocks and their fossils to document the age and history of the Earth.  5. The student will recognize that constructive and destructive Earth processes can affect the evidence of Earth’s history.  6. The student will classify and identify rocks and minerals using characteristics including but not limited to density, hardness and streak.</td>
</tr>
<tr>
<td>GRADE 8</td>
<td>III EARTH AND SPACE SCIENCE</td>
<td>A. Earth Structure and Processes</td>
<td>The student will investigate the impact humans have on the environment.</td>
<td>1. The student will identify and research an environmental issue and evaluate its impact.</td>
</tr>
<tr>
<td>Grade Level</td>
<td>Strand</td>
<td>Sub-Strand</td>
<td>Standard</td>
<td>Benchmarks</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
<td>------------</td>
<td>----------</td>
<td>------------</td>
</tr>
</tbody>
</table>
| GRADE 8     | III. EARTH AND SPACE SCIENCE | B. The Water Cycle, Weather and Climate | The student will investigate how the atmosphere interacts with the Earth system. | 1. The student will define radiation, conduction and convection and explain their effects on weather and climate.  
2. The student will identify the forces that create currents and layers in the Earth’s atmosphere and water systems.  
3. The student will describe the effect of Earth’s rotation on the winds and ocean currents.  
4. The student will collect and use data to predict the weather.  
5. The student will identify the composition and structures of the atmosphere.  
6. The student will describe climate changes that have occurred over time. |
| GRADE 8     | III. EARTH AND SPACE SCIENCE | C. The Universe | The student will compare objects in the solar system and explain their interactions with the Earth. | 1. The student will recognize that the sun is the principal energy source for the solar system and that this energy is transferred in the form of radiation.  
2. The student will explain how the combination of the Earth's tilted axis and revolution around the sun causes the progression of seasons and weather patterns.  
3. The student will compare and contrast the planets, taking into account their composition, mass and distance from the sun and recognize the conditions that have allowed life to flourish on Earth.  
4. The student will use the predictability of the motions of the Earth, and sun to explain the length of day, length of year, phases of the moon, eclipses, tides and shadows. |
### GRADE 8

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Strand</th>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
</table>
| GRADE 8     | III. EARTH AND SPACE SCIENCE | C. The Universe | The student will describe the composition and structure of the universe. | 1. The student will recognize that the universe consists of many billions of galaxies, each containing many billions of stars and that there are vast distances that separate these galaxies and stars from one another.  
2. The student will recognize that the sun is a medium-sized star and is the closest star to Earth. It is the central and largest body in the solar system and is one of billions of stars in the Milky Way Galaxy. |
### A Review of the University of Wisconsin-Superior Secondary Education Science Curriculum

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Strand</th>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
</table>
| GRADE 9–12  | I. HISTORY AND NATURE OF SCIENCE | A. Scientific World View | The student will understand the nature of scientific ways of thinking and that scientific knowledge changes and accumulates over time. | 1. The student will be able to distinguish among hypothesis, theory and law as scientific terms and how they are used to answer a specific question.  
2. The student will be able to explain how scientific and technological innovations as well as new evidence can challenge portions of or entire accepted theories and models including but not limited to cell theory, atomic theory, theory of evolution, plate tectonic theory, germ theory of disease and big bang theory.  
3. The student will recognize that in order to be valid, scientific knowledge must meet certain criteria including that it: be consistent with experimental, observational and inferential evidence about nature; follow rules of logic and reporting both methods and procedures; and, be falsifiable and open to criticism.  
4. The student will explain how traditions of ethics, peer review, conflict and general consensus influences the conduct of science.  
5. The student will recognize that some scientific ideas are incomplete, and opportunity exists in these areas for new advances. |
## A Review of the University of Wisconsin-Superior Secondary Education Science Curriculum

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Strand</th>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
</table>
| GRADE 9–12  | I. HISTORY AND NATURE OF SCIENCE | B. Scientific Inquiry | The student will design and conduct a scientific investigation. | 1. The student will design and complete a scientific experiment using scientific methods by determining a testable question, designing a scientific investigation with appropriate controls, analyzing data, making conclusions based on evidence and comparing conclusions to the original hypothesis and prior knowledge.  
2. The student will distinguish between qualitative and quantitative data.  
3. The student will apply mathematics and models to analyze data and support conclusions.  
4. The student will identify possible sources of error and their effects on results.  
5. The student will know that professional scientists and engineers have ethical codes.  
6. The student will give examples of how different domains of science use different bodies of scientific knowledge and employ different methods to investigate questions. |
<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Strand</th>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRADE 9–12</td>
<td>I. HISTORY AND NATURE OF SCIENCE</td>
<td>C. Scientific Enterprise</td>
<td>The student will understand the relationship between science and technology and how both are used.</td>
<td>1. The student will compare and contrast the purposes and career opportunities of engineering, technology and science. 2. The student will provide an example of a need or problem identified by science and solved by engineering or technology. 3. The student will provide an example of how technology facilitates new discoveries and the development of scientific knowledge. 4. The student will know that technological changes and scientific advances are often accompanied by social, political, environmental and economic changes. 5. The student will recognize that science and technology are influenced by cultural backgrounds and beliefs and by social needs, attitudes, values and limitations.</td>
</tr>
<tr>
<td>GRADE 9–12</td>
<td>I. HISTORY AND NATURE OF SCIENCE</td>
<td>D. Historic Perspectives</td>
<td>The student will recognize the historical and cultural context of scientific endeavors and how they influence each other.</td>
<td>1. The student will be able to trace the development of a scientific advancement, invention or theory and its impact on society. 2. The student will provide examples of scientific advancements contributed by other civilizations and cultures. 3. The student will compare and contrast the differences between scientific theories and theories from other bodies of knowledge, and the importance of each in a science discussion.</td>
</tr>
</tbody>
</table>
A Review of the University of Wisconsin-Superior Secondary Education Science Curriculum

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Strand</th>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
</table>
| GRADE 9–12 | II. PHYSICAL SCIENCE | A. Structure of Matter | The student will understand the nature of matter including its forms, properties and interactions. | 1. The student will identify protons, neutrons and electrons as the major components of the atom, their mass relative to one another, their arrangement and their charge.  
2. The student will be able to explain the relationship of an element’s position on the periodic table to its atomic number and atomic mass.  
3. The student will compare and contrast the properties of an element and its isotopes, and describe how isotopes can be used in research, medicine and industry.  
4. The student will use the periodic table to identify regions, families, groups and periods.  
5. The student will explain how neutral atoms become ions.  
6. The student will be able to explain how atoms form compounds through bonding.  
7. The student will compare and contrast the states of matter in terms of interactions between particles.  
8. The student will differentiate between an atom and a molecule.  
9. The student will differentiate between an element and compound. |
A Review of the University of Wisconsin-Superior Secondary Education Science Curriculum

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Strand</th>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
</table>
| GRADE 9–12  | II. PHYSICAL    | B. Chemical        | The student will describe chemical reactions and the factors that influence them. | 1. The student will describe chemical reactions using words and symbolic equations.  
2. The student will explain the influence of temperature, surface area, agitation and catalysts on the rate of a reaction.  
3. The student will distinguish between a chemical reaction and a nuclear reaction.  
4. The student will explain how the rearrangement of atoms and molecules in a chemical reaction illustrates conservation of mass.  
5. The student will describe how combining acids and bases produce a neutral solution.  |
## A Review of the University of Wisconsin-Superior Secondary Education Science Curriculum

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Strand</th>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRADE 9–12</td>
<td>II. PHYSICAL SCIENCE</td>
<td>C. Energy Transformations</td>
<td>The student will understand energy forms, transformations and transfers.</td>
<td>1. The student will know that potential energy is stored energy and is associated with gravitational or electrical force, mechanical position or chemical composition. 2. The student will differentiate between kinetic and potential energy and identify situations where kinetic energy is converted into potential energy and vice versa. 3. The student will differentiate between AC and DC current. 4. The student will describe the production, storage and transmission of electricity. 5. The student will be able to describe physical and chemical changes in terms of the law of conservation of energy. 6. The student will compare and contrast the amount of energy released through chemical reactions and nuclear fission and fusion. 7. The student will describe the risks and benefits of fossil fuels, renewable sources and nuclear power as sources of usable energy. 8. The student will describe applications of the different wavelengths of the electromagnetic spectrum. 9. The student will describe energy, work and power both conceptually and quantitatively.</td>
</tr>
<tr>
<td>GRADE 9-12</td>
<td>II. PHYSICAL SCIENCE</td>
<td>D. Motion</td>
<td>The student will understand the nature of force and motion.</td>
<td>1. The student will use Newton’s three laws of motion to qualitatively and quantitatively describe the interaction of objects. 2. The student will describe the effect of friction and gravity on the motion of an object.</td>
</tr>
<tr>
<td>Grade Level</td>
<td>Strand</td>
<td>Sub-Strand</td>
<td>Standard</td>
<td>Benchmarks</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------</td>
<td>------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| GRADE 9–12 | II. PHYSICAL SCIENCE     | E. Forces of Nature    | The student will understand the forces of nature and their application. | 1. The student will recognize the factors that affect the presence and magnitude of gravitational, electromagnetic, weak and strong nuclear forces.  
2. The student will identify the dominant force or forces in a variety of interactions.                                                                                                               |
| GRADE 9–12 | III. EARTH AND SPACE SCIENCE | A. Earth Structure and Processes | The student will understand that the interactions of the atmosphere, biosphere, lithosphere, hydrosphere and space have resulted in ongoing change of the Earth system over geologic time. | 1. The student will identify the internal and external sources of energy for the Earth.  
2. The student will apply the laws of thermodynamics to explain the cycling of materials and transfer of energy in the Earth system.  
3. The student will illustrate how biological processes have played significant roles in determining the character of the atmosphere, biosphere, hydrosphere and lithosphere over time.  
4. The student will use the theory of plate tectonics to analyze relationships among earthquakes, volcanoes, mountains, fossil deposits, rock layers and ocean features.  
5. The student will describe how glaciers, gravity, wind, temperature changes, waves and rivers cause weathering and erosion.  
6. The student will describe the rock cycle and compare and contrast the processes responsible for the formation of igneous, sedimentary and metamorphic rocks.  
7. The student will use evidence found in fossils, rock layers, ice cores, radiometric dating and globally gathered data to explain how Earth has changed over short and long periods of time. |
<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Strand</th>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRADE 9-12</td>
<td>III EARTH AND SPACE SCIENCE</td>
<td>A. Earth Structure and Processes</td>
<td>The student will investigate the impact humans have on the environment.</td>
<td>1. The student will identify and research an environmental issue and evaluate its impact.</td>
</tr>
<tr>
<td>GRADE 9–12</td>
<td>III. EARTH AND SPACE SCIENCE</td>
<td>B. The Water Cycle, Weather and Climate</td>
<td>The student will explain the causes and effects of the Earth’s atmospheric and hydrologic processes.</td>
<td>1. The student will explain how the transfer of energy and motions of the Earth contribute to global climatic processes including wind, waves and ocean currents. 2. The student will trace the cyclical movement of carbon and water through the lithosphere, hydrosphere, atmosphere and biosphere. 3. The student will demonstrate the effect of the Earth’s tilt, rotation and revolution on the seasons, day length and tides. 4. The student will identify, predict and investigate the factors that influence the quality of water and how it can be reused, recycled and conserved. 5. The student will discuss the impact of the use of natural resources and other human activities on the Earth’s climate.</td>
</tr>
<tr>
<td>GRADE 9–12</td>
<td>III. EARTH AND SPACE SCIENCE</td>
<td>C. The Universe</td>
<td>The student will relate the formation and components of our solar system to the conditions necessary for life.</td>
<td>1. The student will explain how the sun, Earth and solar system formed. 2. The student will compare the characteristics of Earth with the characteristics and movement patterns of the other planets, their satellites and other objects in our solar system. 3. The student will compare and contrast the environmental parameters that make life possible on Earth with conditions found on the other planets of our solar system.</td>
</tr>
<tr>
<td>Grade Level</td>
<td>Strand</td>
<td>Sub-Strand</td>
<td>Standard</td>
<td>Benchmarks</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------------</td>
<td>------------</td>
<td>---------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| GRADE 9–12  | III. EARTH AND SPACE SCIENCE| C. The Universe | The student will use astronomical data to reveal the structure, scale, and changes in the stars, galaxies and universe over time.  | 1. The student will identify different types of stars and galaxies and describe how stars, galaxies and the universe change over time.  
2. The student will explain how nuclear fusion produces energy and other elements.  
3. The student will describe the evidence from current technologies that has been used to understand the composition and the early history of the universe.  
4. The student will explain how Doppler evidence indicates our universe is expanding in all directions.                                                                 |
| GRADE 9–12  | IV. LIFE SCIENCE            | A. Cells   | The student will comprehend that all living things are composed of cells, and that the life processes in a cell are based on molecular interactions. | 1. The student will relate cellular structures to their functions.  
2. The student will compare and contrast the structures found in typical plant, animal and bacterial cells.  
3. The student will explain the role of the cell membrane as a highly selective barrier in diffusion, osmosis and active transport.  
4. The student will describe the role of enzymes as catalysts in metabolism and cellular synthesis of new molecules.  
5. The student will differentiate between the processes of photosynthesis and respiration in terms of energy flow, reactants and products.  
6. The student will describe and compare the processes of mitosis and meiosis and their roles in the cell cycle. |
### A Review of the University of Wisconsin-Superior Secondary Education Science Curriculum

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Strand</th>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
</table>
| GRADE 9–12  | IV. LIFE SCIENCE        | B. Diversity of Organisms       | The student will classify, compare and contrast the diversity of organisms on Earth and their modes of accommodating the requirements for life. | 1. The student will relate the structure, complexity and organization of organ systems to the methods of obtaining, transforming, releasing and eliminating the matter and energy used to sustain the organism.  
2. The student will recognize that organisms have both innate and learned behavioral responses to internal and external stimuli, including the tropic responses in plants.  
3. The student will use scientific evidence, including the fossil record, homologous structures, embryological development or biochemical similarities, to classify organisms in order to show probable evolutionary relationships and common ancestry. |
| GRADE 9–12  | IV. LIFE SCIENCE        | C. Interdependence of Life      | The student will describe how the environment and interactions between organisms can affect the number of species and the diversity of species in an ecosystem. | 1. The student will describe the factors related to matter and energy in an ecosystem that both influence fluctuations in population size and determine the carrying capacity of a population.  
2. The student will explain how adaptations of species and co-evolution with other species are related to success in an ecosystem.  
3. The student will identify examples of mutualism, commensalism, and parasitism in a stable ecosystem.  
4. The student will predict and analyze how a change in an ecosystem, resulting from natural causes, changes in climate, human activity or introduction of invasive species, can affect both the number of organisms in a population and the biodiversity of species in the ecosystem. |
### Grade Level | Strand | Sub-Strand | Standard | Benchmarks
---|---|---|---|---
GRADE 9–12 | IV. LIFE SCIENCE | D. Heredity | The student will explain how inherited characteristics are encoded by genes. | 1. The student will explain that the instructions for the characteristics of all organisms are carried in nucleic acids.  
2. The student will define the relationship between DNA, genes and chromosomes.  
3. The student will describe the structure and function of DNA and distinguish between replication, transcription and translation.  
4. The student will know that different species of multicellular organisms have a characteristic number of chromosomes, and that in typical humans there are 22 autosomal pairs and 2 sex chromosomes.  
5. The student will describe how genetic information is transmitted from parents to offspring through the processes of meiosis and fertilization as they relate to chromosome recombination and sexual reproduction.  
6. The student will use Mendel’s laws of segregation and independent assortment to determine the genotype and phenotype of a monohybrid cross.  
7. The student will differentiate between dominant, recessive, codominant, incompletely dominant, polygenic and sex-linked traits. |
<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Strand</th>
<th>Sub-Strand</th>
<th>Standard</th>
<th>Benchmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRADE 9–12</td>
<td>IV. LIFE SCIENCE</td>
<td>E. Biological Populations Change Over Time</td>
<td>The student will understand how biological evolution provides 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.</td>
<td>1. The student will understand that species change over time and the term biological evolution is used to describe this process. 2. The student will use the principles of natural selection to explain the differential survival of groups of organisms as a consequence of: o The potential for a species to increase its numbers; o The genetic variability of offspring due to mutation and recombination of genes; o A finite supply of the resources required for life; and, o The ensuing selection based on environmental factors of those offspring better able to survive and produce reproductively successful offspring. 3. The student will describe how genetic variation between populations is due to different selective pressures acting on each population, which can lead to a new species. 4. The student will use biological evolution to explain the diversity of species.</td>
</tr>
<tr>
<td>Grade Level</td>
<td>Strand</td>
<td>Sub-Strand</td>
<td>Standard</td>
<td>Benchmarks</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
<td>--------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| GRADE 9–12  | IV. LIFE     | F. Flow of Matter and Energy   | The student will describe and explain the cycling of matter and flow of energy through an ecosystem’s living and non-living components. | 1. The student will explain the relationship between abiotic and biotic components of an ecosystem in terms of the cycling of water, carbon, oxygen and nitrogen.  
2. The student will know that all matter tends to become more disorganized over time, and that living systems require a continuous input of energy in order to maintain their chemical and physical organizations and prevent death.  
3. The student will explain that sunlight is transformed into chemical energy by photosynthetic organisms.  
4. The student will explain that respiration releases chemical energy through the breakdown of molecules.  
5. The student will understand that matter and energy flow through different levels of organization of living systems, from cells to communities, as well as between living systems and the physical environment as chemical elements are recombined in different ways. Each recombination results in both storage and dissipation of energy. |
| GRADE 9–12  | IV. LIFE     | G. Human Organism              | The student will understand how all organ systems, including the nervous system, interact to maintain homeostasis. | 1. The student will understand and describe the basic anatomy and physiology of the nervous system and sense organs.  
2. The student will describe how the functions of individual organ systems are integrated to maintain a homeostatic balance in the body.                                                                                           |
A Review of the University of Wisconsin-Superior Secondary Education Science Curriculum

Works Cited


A Review of the University of Wisconsin-Superior Secondary Education Science Curriculum


Teacher education program approval and licenses. (2000). Wisconsin Department of Public Instruction: PI 34. (ERIC Document Reproduction Service No. ED 446093.)