Correlation of STARLAB Cylinders to the National Science Education Standards — Grades 9-12

The National Science Education Standards establish a series of goals designed to improve the scientific literacy of American students. In developing the standards, one of the main goals was to focus on the inquiry aspects of science education rather than just the content that is taught. Since its inception more than 25 years ago, the main focus of the STARLAB Planetarium system has been just that. Instead of simply being a place where students can "see the sky", the various STARLAB cylinders that are used with the analog Standard and FiberArc STARLAB projectors were developed with the concept of student participation as a central theme. Since many state education departments and school districts use the National Science Education Standards as a framework for creating their core curricula in science, we offer the following correlation between the STARLAB cylinders and the standards.

The following pages show which STARLAB cylinders can be used to help students meet each of the National Science Education Standards. We have included the correlations with the Content Standards including Science as Inquiry, Physical Science, Life Science, Earth and Space Science, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science.

9-12 Science As Inquiry — Cylinder Key:

SP1 = Milky Way Starfield	SP5 = Solar System/Galaxy	SP7 = Radio Sky	SP8 = Moon
ES2 = Plate Tectonics	ES3 = Ocean Currents	ES4 = Weather	OS1 = Biological Cell

9-12 Science as Inquiry Standards and the corresponding STARLAB Cylinders that help meet those standards

Understandings About Scientific Inquiry	SP1	SP5	SP7	SP8	ES2	ES3	ES4	OS1
Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.	✔	✔	✔	✔	✔	✔	✔	✔
Scientists conduct investigations for a wide variety of reasons. For example, they may wish to discover new aspects of the natural world, explain recently observed phenomena, or test the conclusions of prior investigations or the predictions of current theories.	✔	✔	✔	✔	✔	✔	✔	✔
Scientists rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used.	✔	✔	✔	✔	✔	✔	✔	✔
Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results.		✔			✔			
Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge.	✔	✔	✔	✔	✔			✔

9-12 Physical Science — Cylinder Key:

SP1 = Milky Way Starfield SP5 = Solar System/Galaxy SP7 = Radio Sky OS1 = Biological Cell

9-12 Physical Science Standards and the corresponding STARLAB Cylinders that help meet those standards				
Structure of Atoms	SP1	SP5	SP7	OS1
The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars.	✔	✔	✔	
Chemical Reactions				
Chemical reactions occur all around us, for example in health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies.				✔
Catalysts, such as metal surfaces, accelerate chemical reactions. Chemical reactions in living systems are catalyzed by protein molecules called enzymes.				✔
Motions and Forces				
Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.		✔		
Interactions of Energy and Matter				
Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.			✔	
Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.			✔	
Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance.	✔			

9-12 Life Science — Cylinder Key:

SP5 = Solar System/Galaxy ES2 = Plate Tectonics OS1 = Biological Cell OS2 = Bird Migration

9-12 Life Science Standards and the corresponding STARLAB Cylinders that help meet those standards				
The Cell	SP5	ES2	OS1	OS2
Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and the storage of genetic material.			✔	
Most cell functions involve chemical reactions. Food molecules taken into cells react to provide the chemical constituents needed to synthesize other molecules. Both breakdown and synthesis are made possible by a large set of protein catalysts, called enzymes. The breakdown of some of the food molecules enables the cell to store energy in specific chemicals that are used to carry out the many functions of the cell.			✔	
Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires.			✔	
Cell functions are regulated. Regulation occurs both through changes in the activity of the functions performed by proteins and through the selective expression of individual genes. This regulation allows cells to respond to their environment and to control and coordinate cell growth and division.			✔	
Plant cells contain chloroplasts, the site of photosynthesis. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital connection between the sun and the energy needs of living systems.			✔	
Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. In the development of these multicellular organisms, the progeny from a single cell form an embryo in which the cells multiply and differentiate to form the many specialized cells, tissues and organs that comprise the final organism. This differentiation is regulated through the expression of different genes.			✔	
The Molecular Basis of Heredity				
In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "letters") and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.			✔	
Most of the cells in a human contain two copies of each of 22 different chromosomes. In addition, there is a pair of chromosomes that determines sex: a female contains two X chromosomes and a male contains one X and one Y chromosome. Transmission of genetic information to offspring occurs through egg and sperm cells that contain only one representative from each chromosome pair. An egg and a sperm unite to form a new individual. The fact that the human body is formed from cells that contain two copies of each chromosome--and therefore two copies of each gene--explains many features of human heredity, such as how variations that are hidden in one generation can be expressed in the next.			✔	
Changes in DNA (mutations) occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism's offspring.			✔	

9-12 Life Science — Cylinder Key:

SP5 = Solar System/Galaxy ES2 = Plate Tectonics OS1 = Biological Cell OS2 = Bird Migration

Biological Evolution	SP5	ES2	OS1	OS2
The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms.		✔	✔	
Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms.		✔	✔	
The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.		✔	✔	
Matter, Energy, and Organization on Living Systems				
The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules. These molecules can be used to assemble larger molecules with biological activity (including proteins, DNA, sugars, and fats). In addition, the energy stored in bonds between the atoms (chemical energy) can be used as sources of energy for life processes.	✔		✔	
The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed. Cells usually store this energy temporarily in phosphate bonds of a small high-energy compound called ATP.			✔	
The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.				✔
As matter and energy flows through different levels of organization of living systems--cells, organs, organisms, communities--and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change.			✔	
The Behavior of Organisms				
Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.				✔
Like other aspects of an organism's biology, behaviors have evolved through natural selection. Behaviors often have an adaptive logic when viewed in terms of evolutionary principles.				✔

9-12 Earth and Space Science — Cylinder Key:

SP4 = Deep Sky Objects
SP5 = Solar System/Galaxy
SP7 = Radio Sky
ES1 = Earth
ES2 = Plate Tectonics
ES3 = Ocean Currents
ES4 = Weather
ES5 = Geocentric Earth
OS1 -= Biological Cell

9-12 Earth and Space Science Standards and the corresponding STARLAB Cylinders that help meet those standards									
Energy in the Earth System	SP4	SP5	SP7	ES1	ES2	ES3	ES4	ES5	OS1
Earth systems have internal and external sources of energy, both of which create heat. The sun is the major external source of energy. Two primary sources of internal energy are the decay of radioactive isotopes and the gravitational energy from the earth's original formation.		✔			✔	✔	✔		
The outward transfer of earth's internal heat drives convection circulation in the mantle that propels the plates comprising earth's surface across the face of the globe.					✔				
Heating of earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.						✔	✔		
Global climate is determined by energy transfer from the sun at and near the earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover and the earth's rotation, and static conditions such as the position of mountain ranges and oceans.				✔	✔	✔	✔	✔	
Geochemical Cycles									
The earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs. Each element on earth moves among reservoirs in the solid earth, oceans, atmosphere, and organisms as part of geochemical cycles.					✔	✔	✔		✔
Movement of matter between reservoirs is driven by the earth's internal and external sources of energy. These movements are often accompanied by a change in the physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as carbon dioxide gas, in water as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life.					✔	✔	✔		✔
The Origin and Evolution of the Earth System									
The sun, the earth, and the rest of the solar system formed from a nebular cloud of dust and gas 4.6 billion years ago. The early earth was very different from the planet we live on today.	✔	✔	✔		✔				
Interactions among the solid earth, the oceans, the atmosphere, and organisms have resulted in the ongoing evolution of the earth system. We can observe some changes such as earthquakes and volcanic eruptions on a human time scale, but many processes such as mountain building and plate movements take place over hundreds of millions of years.					✔				
The Origin and Evolution of the Universe									
Early in the history of the universe, matter, primarily the light atoms hydrogen and helium, clumped together by gravitational attraction to form countless trillions of stars. Billions of galaxies, each of which is a gravitationally bound cluster of billions of stars, now form most of the visible mass in the universe.	✔	✔	✔						

9-12 Science and Technology — Cylinder Key:

SP1 = Milky Way Starfield
SP4 = Deep Sky Objects
SP5 = Solar System/Galaxy
SP7 = Radio Sky
SP8 = Moon
ES2 = Plate Tectonics
ES3 = Ocean Currents
ES4 = Weather
OS1 = Biological Cell

9-12 Science and Technology Standards and the corresponding STARLAB Cylinders that help meet those standards

Understandings About Science and Technology	SP1	SP4	SP5	SP7	SP8	ES2	ES3	ES4	OS1
Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research.	✔	✔	✔	✔	✔	✔	✔	✔	✔

9-12 Science in Personal and Social Perspectives — Cylinder Key:

ES2 = Plate Tectonics ES4 = Weather SS1 = Maya Skies SS2 = Lewis & Clark Celestial Navigation SS3 = The Civil War Sky

9-12 Science in Personal and Social Perspectives Standards and the corresponding STARLAB Cylinders that help meet those standards

Population Growth	ES2	ES4	SS1	SS2	SS3
Populations grow or decline through the combined effects of births and deaths, and through emigration and immigration. Populations can increase through linear or exponential growth, with effects on resource use and environmental pollution.				✔	
Populations can reach limits to growth. Carrying capacity is the maximum number of individuals that can be supported in a given environment. The limitation is not the availability of space, but the number of people in relation to resources and the capacity of earth systems to support human beings. Changes in technology can cause significant changes, either positive or negative, in carrying capacity.				✔	
Natural Resources					
Human populations use resources in the environment in order to maintain and improve their existence. Natural resources have been and will continue to be used to maintain human populations.				✔	
Environmental Quality					
Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, overconsumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and different ways humans view the earth.			✔	✔	✔
Natural and Human-Induced Hazards					
Normal adjustments of earth may be hazardous for humans. Humans live at the interface between the atmosphere driven by solar energy and the upper mantle where convection creates changes in the earth's solid crust. As societies have grown, become stable, and come to value aspects of the environment, vulnerability to natural processes of change has increased.	✔	✔			
Some hazards, such as earthquakes, volcanic eruptions, and severe weather, are rapid and spectacular. But there are slow and progressive changes that also result in problems for individuals and societies. For example, change in stream channel position, erosion of bridge foundations, sedimentation in lakes and harbors, coastal erosions, and continuing erosion and wasting of soil and landscapes can all negatively affect society.	✔	✔			
Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students should understand the costs and trade-offs of various hazards--ranging from those with minor risk to a few people to major catastrophes with major risk to many people. The scale of events and the accuracy with which scientists and engineers can (and cannot) predict events are important considerations.	✔	✔			

9-12 History and Nature of Science — Cylinder Key:

SP1 = Milky Way Starfield
SP4 = Deep Sky Objects
SP5 = Solar System/Galaxy
SP7 = Radio Sky
SP8 = Moon
MY1 = Greek Mythology
MY2 = African Mythology
MY3 = Ancient Egyptian Mythology
MY4 = Native American Mythology
MY5 = Navajo Skies
MY6 = Ancient Chinese Legends
MY7 = Ancient Chinese Season
MY8 = Lapp/Samí Mythology
MY9 = Hindu Mythology
MY10 = Inuit Starlore
SS1 = Maya Skies
SS3 = Civil War Sky
SS4 = Polynesian Voyaging
ES2 = Plate Tectonics
ES3 = Ocean Currents
ES4 = Weather
OS1 = Biological Cell

9-12 History & Nature of Science Standards and the corresponding STARLAB Cylinders that help meet those standards									
Science as a Human Endeavor	SP1	SP4	SP5	SP7	SP8	ES2	ES3	ES4	OS1
Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem. Pursuing science as a career or as a hobby can be both fascinating and intellectually rewarding.	✔	✔	✔	✔	✔	✔	✔	✔	✔
Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. Science is not separate from society but rather science is a part of society.	✔	✔	✔	✔	✔	✔	✔	✔	✔
Nature of Scientific Knowledge									
Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world.	✔	✔	✔	✔	✔	✔	✔	✔	✔

Nature of Scientific Knowledge (cont'd)	SP 1	SP 4	SP 5	SP 7	SP 8	MY 1	MY 2	MY 3	MY 4	MY 5	MY 6	MY 7	MY 8	MY 9	MY 10	SS 1	SS 3	SS 4	ES 2	ES 3	ES 4	OS 1
Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

9-12 History and Nature of Science — Cylinder Key:

SP1 = Milky Way Starfield
SP4 = Deep Sky Objects
SP5 = Solar System/Galaxy
SP7 = Radio Sky
SP8 = Moon
ES2 = Plate Tectonics
ES3 = Ocean Currents
ES4 = Weather
SS2 = Lewis & Clark Celestial Navigation
OS1 = Biological Cell

Nature of Scientific Knowledge (cont'd)	SP1	SP4	SP5	SP7	SP8	ES2	ES3	ES4	SS2	OS1
Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core ideas of science such as the conservation of energy or the laws of motion have been subjected to a wide variety of confirmations and are therefore unlikely to change in the areas in which they have been tested. In areas where data or understanding are incomplete, such as the details of human evolution or questions surrounding global warming, new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest.	✔	✔	✔	✔	✔	✔	✔	✔		✔
Historical Perspectives										
In history, diverse cultures have contributed scientific knowledge and technologic inventions. Modern science began to evolve rapidly in Europe several hundred years ago. During the past two centuries, it has contributed significantly to the industrialization of Western and non-Western cultures. However, other, non-European cultures have developed scientific ideas and solved human problems through technology.	✔	✔	✔	✔	✔	✔	✔	✔		✔
Usually, changes in science occur as small modifications in extant knowledge. The daily work of science and engineering results in incremental advances in our understanding of the world and our ability to meet human needs and aspirations. Much can be learned about the internal workings of science and the nature of science from study of individual scientists, their daily work, and their efforts to advance scientific knowledge in their area of study.	✔	✔	✔	✔	✔	✔	✔	✔		✔
Occasionally, there are advances in science and technology that have important and long-lasting effects on science and society. Examples of such advances include the following: Copernican revolution, Newtonian mechanics, Relativity, Geologic time scale, Plate tectonics, Atomic theory, Nuclear physics, Biological evolution, Germ theory, Industrial revolution, Molecular biology, Information and communication, Quantum theory, Galactic universe, Medical and health technology.	✔	✔	✔	✔	✔	✔			✔	✔
The historical perspective of scientific explanations demonstrates how scientific knowledge changes by evolving over time, almost always building on earlier knowledge.	✔	✔	✔	✔	✔	✔	✔	✔		✔