Targeting the Next Generation Science Standards With a Digitarium® Digital Planetarium System

For more information about NGSS, visit: http://www.nextgenscience.org/

Note: Below are some sample ideas for targeting specific Disciplinary Core Ideas (DCI) with a Digitarium planetarium system. These are certainly not the only DCI that can be targeted: With some creativity, many other DCI in other subject areas can be discussed in the engaging, immersive dome environment, especially through use of the multimedia functions.

Targeting DCI at Different Grades: Elementary School

Grade	DCI Number/Text	Planetarium Activities Summary
K	K-PS3.B, Conservation of Energy and Energy Transfer: Sunlight warms Earth's surface.	Start in the day time sky, and have the students point to the sun. Fast forward time to allow the sun to set, while the students track the path of the sun across the sky with their arm. Discuss with students, When is it warmer: Day time or night time? Why is it warmer during the day? Why do humans need the sun? What else needs light from the sun (plants, for example)?
1	1-PS4.B: Electromagnetic Radiation: Objects can be seen if light is available to illuminate them or if they give off their own light.	Discuss why we can see stars and why we can see the moon. Use a laser pointer to illustrate light reflecting off the dome surface back to the students' eyes. Spray safe, odorless “Fog in a Can” in the path of the laser to demonstrate that the light from the laser is invisible until it reflects/bounces off something back to the students' eyes. COMMON SENSE CAUTIONS: Do not aim the laser pointer at anyone's eyes or spray the Fog in a Can directly into anyone's face or eyes!
1	1-PS4.B: Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam.	Use a laser pointer and various objects to demonstrate this, for example: Pieces of mirror (be careful not to reflect the laser into anyone's eyes); lenses, such as a magnifying glass or eyeglass lens; piece of cardboard to block the light; etc.
1	1-ESS1.A, The Universe and Its Stars: Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.	Have students observe the daytime sky while time is fast-forwarding. Have students track the sun with one arm as it crosses the sky. Using the night time sky, have students track the path of a particular star or constellation.

1	1-ESS1.B, Earth and the Solar System: Seasonal patterns of sunrise and sunset can be observed, described, and predicted.	With the planetarium clock displayed and compass points turned on, run time forward from midnight to sunrise on the two solstices and two equinoxes. If possible, record the rising times and general rising positions (i.e., East, Northeast) for each of the four dates. See the “Solar Motion” Augmented Lesson for more activities, including scripts to run time lapses on each equinox and solstice. Discuss with students when it stays light later—in the summer or the winter? Do they ever go to bed when the sun is still up? Depending on your latitude, some students may answer that the sun is sometimes still up when they go to bed in the summer. Note: Most students in first grade cannot think abstractly and will not be able to understand WHY Earth's tilt causes seasons.
2	2-ESS1.C, The History of Planet Earth: Some events happen very quickly; others occur very slowly over a time period much longer than one can observe.	(Requires high resolution Earth terrain data or images/videos) Fly over parts of Earth's surface and discuss how those features were formed. Alternatively you can display images or videos to cover these topics. For example: Short term changes: Fly over Mt St Helens (in Washington state). Longer term changes: Fly over the Hawaiian islands, and discuss their formation.
2	2-ESS2.A, Earth Materials and Systems: Wind and water can change the shape of land.	(Requires high resolution Earth terrain data or supplemental images/videos) Discuss erosion with students, showing areas of significant erosion such as the Mississippi River Delta region. Show images of “mushroom rocks,” such as the limestone formations of the White Desert in Egypt.
2	2-ESS2.B, Plate Tectonics and Large Scale System Interactions: Maps show where things are located. One can map the shapes and kinds of land and water in any area.	Using the multimedia software, display an image of Earth with the tectonic plates labeled. The “Plate Tectonics” Augmented Lesson (estimated release summer 2019) will address this topic in detail, via Science on a Sphere plate tectonics data sets.
2	2-ESS2.C, The Roles of Water in Earth's Surface Processes: Water is found in the oceans, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.	Run the local script to visit the moon, then zoom in on Earth. You can easily see oceans and polar caps from this view. (Requires high resolution Earth terrain data or images/videos) Fly over parts of Earth's surface and discuss bodies of water. For example, fly over the Great Lakes, Puget Sound, Lake Pontchartrain, etc. There are several Science on a Sphere data sets that address water on Earth. These can be mapped to the earth in Nightshade NG via StratoScripts.

3	3-PS2.A, Forces and Motion: The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it.	Discuss planetary motion and moon phases, using time lapses as desired to make the motions more obvious.
3	3-ESS2.D, Weather and Climate: Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.	There are several Science on a Sphere data sets that address these topics. These can be mapped to the earth in Nightshade NG via StratoScripts. Discuss the local weather forecast with students, and how /whyshort range forecasts are more accurate than long range.
4	4-PS3.B, Conservation of Energy and Energy Transfer: Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. [...]	Discuss collisions in space while displaying media. For example: Mergers of galaxies or “the big whack” as a theory of the moon's formation.
4	4-PS3.C, Relationship Between Energy and Forces: When objects collide, the contact forces transfer energy so as to change the objects' motions.	As above, discuss collisions in space while displaying media. If you have a Newton's Cradle, use it to demonstrate transfer of momentum.
4	4-PS4.A, Wave Properties: Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).	Show an image of the electromagnetic spectrum, and discuss how it shows different types of light. Point out the section of the spectrum dedicated to visible light, and note that some types of light (infrared, microwave, radio) have longer wavelengths than visible light while other types (ultraviolet, x-rays, gamma rays) have shorter wavelengths than visible light. Discuss amplitude with a piece of rope and two volunteers. With each volunteer holding one end of the rope, challenge them to move the rope up and down to make short waves or tall waves (different amplitudes) with different amounts of space between waves (different wavelengths).
4	4-PS4.B, Electromagnetic Radiation: An object can be seen when light reflected from its surface enters the eyes.	As with 1-PS4.B, Use a laser pointer to illustrate light reflecting off the dome surface back to the students' eyes. Spray safe, odorless “Fog in a Can” in the path of the laser to make it visible.

4	4-ESS1.C, the History of Planet Earth: Local, regional, and global patterns of rock formations reveal changes over time due to Earth's forces, such as earthquakes. [...]	There are several Science on a Sphere data sets that address these topics. These can be mapped to the earth in Nightshade NG via StratoScripts. Use media to highlight geologic points of interest such as the San Andreas fault, display videos of Pangea over time, etc. (Requires high resolution Earth terrain data or images/videos) Fly over areas of interest, such as the San Andreas fault. Use the “Earthquakes” Augmented Lesson for easy presentation of activities.
4	4-ESS2.A, Earth Materials and Systems: Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.	There are several Science on a Sphere data sets that address these topics. These can be mapped to the earth in Nightshade NG via StratoScripts. As noted above in targeting 2-ESS2.A, discuss erosion with students, showing areas such as the Mississippi River Delta region, where water has moved sediment over time. This is clearly visible with add-on high resolution data sets for Nightshade NG.
4	4-ESS2.B, Plate Tectonics and Large-Scale System Interactions: The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth.	(Requires high resolution Earth terrain and topography data) Fly students over different parts of the earth, such as: * The Olympic Mountains in Washington state, which were formed by uplifted seafloor. * The Appalachian Mountain range that runs along most of the US East Coast were formed by two tectonic plates running into each other. The “Plate Tectonics” Augmented Lesson (estimated release January 2019) will address this topic in detail, via Science on a Sphere plate tectonics data sets.
5	5-ESS1.A, Earth's Place in the Universe, The Universe and Its Stars: The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth.	With a daytime sky or cove lights on for illumination: Use two tennis balls to discuss this concept: Position one tennis ball near a student volunteer and the other far away. Which looks bigger? Have the student hold and compare both tennis balls side by side. Note: This does not translate exactly to stars, as stars do come in different sizes. There are red giant stars that have much greater volume than the sun (point out Betelgeuse in Orion or Antares in Scorpius), but these are so much more distant that they appear much smaller than the sun.

5	5-ESS1.B, Earth and the Solar System: The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its north and south poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.	Fly off Earth, turn on solar system body orbits, and maneuver to show different views of the solar system. Select and center on the Sun, then fast forward time to show planets orbiting the Sun. Select Earth, then fly close enough to Earth that the moon orbiting Earth becomes visible. Fast forward time to highlight the moon orbiting the sun, and point out that half of the moon is always reflecting light from the sun. From Earth: Discuss moon phases as time goes by, with the moon against the background of the sky and zoomed in on the moon. Have students find a constellation (using a star map to locate it, if time permits), then observe that constellation week by week over several months. Are they eventually able to predict where they will see the constellation?
5	5-ESS2.A, Earth's Systems, Earth Materials and Systems: Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). [...]	There are several Science on a Sphere data sets that address these topics. These can be mapped to the earth in Nightshade NG via StratoScripts.
5	5-ESS2.C, The Roles of Water in Earth's Surface Processes: Nearly all of Earth's available water is in the ocean.	There are several Science on a Sphere data sets that address these topics. These can be mapped to the earth in Nightshade NG via StratoScripts. Run the Visit the Moon script, then zoom in on Earth. If necessary, jump week by week until you reach a “full Earth”--i.e., the entire surface facing you is reflecting light from the sun. Fast forward time to show Earth rotating on its axis, and highlight the size of the oceans as compared to continents.

Targeting Middle School Standards

DCI Number/Text	Planetarium Activities Summary
MS-PS1.A, Matter and Its Interactions, Structure and Properties of Matter: Substances are made from different types of atoms, which combine with one another in various ways.	Discuss stellar evolution/nuclear fusion. If desired, show images of different atom structures using the media software, or (if using Nightshade NG Professional) software, load 3D models of different atoms and explore them live with the students.
MS-PS1.B, Chemical Reactions: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.	Discuss stellar evolution/nuclear fusion, as above.
MS-PS2.B: Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.	Fly off Earth, turn on solar system body orbit lines, then fly out far enough to show planets orbiting the Sun. Discuss how gravity keeps the bodies in their orbits.
MS-PS4.A: A sound wave needs a medium through which it is transmitted.	Discuss the well-known movie sentence, “In space no one can hear you scream.” Sound cannot travel through space as air molecules are too far apart for transmission. Use a slinky to demonstrate a compression wave: With two volunteers each holding the end of a slinky, pull back several coils of a slinky and let it travel to the other end and bounce back. Students should see the wave travel as slinky coils compress and expand.
MS-PS4.B, Electromagnetic Radiation: When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object’s material and the frequency (color) of the light.	Using white light from a flashlight, put different objects in the path. Color filters will highlight how all wavelengths except that particular color are blocked.
MS-PS4.B: The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.	As with 1-PS4.B above, aim a laser pointer at the dome zenith and put various objects in its path (be careful not to reflect laser light into anyone's eyes!) You can also discuss gravitational lensing, showing images of the Einstein Cross, etc.

MS-ESS1.A, Earth's Place in the Universe, The Universe and Its Stars: Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.	As with earlier grades, have students observe the daytime sky while time is fast-forwarding. Using the night time sky, have students track the path of a particular star or constellation. Have students observe the moon as it phases against the background sky (turn off atmospheric effects to do this with a daytime sky). Can they predict which phase the moon will be in you jump ahead a week? Model the reason for moon phases with the “moon on a stick” activity described in Digitalis's StellarLunar lesson.
MS-ESS1.A: Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.	Use the Sky Engine or multimedia viewer to discuss other galaxies, such as M31/the Andromeda Galaxy. With Nightshade NG Pro: * Take students outside of the Milky Way. Turn on constellation lines to show approximately where Earth is in the Milky Way (Earth is too small to be seen from this distance). * Turn on the Sloan Digital Sky Survey data and discuss how each dot represents a galaxy.
MS-ESS1.B, Earth and the Solar System: The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.	As above in MS-PS2.B, fly off Earth, turn on solar system body orbit lines, then fly out far enough to show planets orbiting the Sun. Discuss how gravity keeps the bodies in their orbits.
MS-ESS1.B: This model of the solar system can explain eclipses of the sun and the moon. Earth’s spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	See Digitalis's “Solstices and Equinoxes” lesson for ideas on broaching this topic. Discuss with students why we don't experience a solar or lunar eclipse every month. Display the ecliptic and show how the moon periodically crosses the ecliptic as it travels around Earth (the moon is inclined about five degrees to the ecliptic). Display historical or future solar or lunar eclipses, such as the August 21, 2017 solar eclipse that was visible from much of the US and the April 8, 2024 eclipse (https://www.greatamericaneclipse.com/april-8-2024/).

Targeting High School Standards

DCI Number/Text	Planetarium Activities Summary
HS-PS2.B, Types of Interactions: Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.	NOTE: The planetarium is a good tool for introducing Newton's law of universal gravitation and observations of its effects. However, it is not the ideal environment for doing the relatively high level math required to show WHY this and Coulomb's law are good predictors. Those topics are better suited to flat screens (white boards, etc.).
HS-PS2.B: Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	Using the multimedia software, show images of the various fields around planets—for example, Earth's magnetic and gravitational fields. Discuss how electric and magnetic fields are related, and how one can be used to induce the other (spinning magnets can generate electricity, etc.). Suggested background sources: https://en.wikipedia.org/wiki/Gravity_of_Earth , https://www.quora.com/Magnetic-Induction-How-exactly-can-magnets-generate-electricity
HS-PS3.A: At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	Discussion topics: light from the sun is converted to heat as the sun's rays warm the earth's surface. Collisions between objects can lead to changes in motion. Sound cannot travel through space as it requires a medium to travel through, but light can.
HS-PS3.B: The availability of energy limits what can occur in any system.	Use stellar evolution/nuclear fusion as an example: Eventually the star will run out of material to convert, and the reaction will stop.
HS-PS4.B, Electromagnetic Radiation: Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.	Show an image of the electromagnetic spectrum, and discuss how the various wavelengths are used in our everyday lives. Discuss the limitations of both the wave and particle models of light. Suggested background: https://en.wikipedia.org/wiki/Wave%E2%80%93particle_duality
HS-ESS1.A, Earth's Place in the Universe, The Universe and Its Stars: The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.	Use the Hertzsprung-Russell diagram and star life cycle charts to discuss stellar evolution for different types of stars, in particular a main sequence star such as the sun. Point out stars in the sky in different phases of their life cycles. Background resources: https://www.nasa.gov/audience/forstudents/9-12/features/stellar_evol_feat_912.html , https://en.wikipedia.org/wiki/Stellar_evolution

HS-ESS1.A: The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	If possible, have students observe various glowing gases with diffraction grating to see the resulting spectra (several companies sell kits for this purpose, including: http://www.arborsci.com/spectrum-analysis-classroom-set). Show spectroscopic fingerprints of different elements including hydrogen and helium. For example: http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/atspect.html
HS-ESS1.A: The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.	Use software scripts to show the sky in other wavelengths, including the CMB. Display media of other galaxies. The Space Telescope Science Institute website is a good source: http://hubblesite.org/images/news/4-galaxies Discuss spectroscopy (as above) for determining stellar composition. See the "How Do We Know?" lesson from Digitalis for more ideas on addressing the Big Bang.
HS-ESS1.A: Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.	Discuss nuclear fusion and spectroscopy (both described above). Show media of supernova remnants and discuss stellar evolution (see above).
HS-ESS1.B, Earth and the Solar System: Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.	Run the local script "Solar System Observer," and discuss the orbits of the planets around the sun. For more information on Kepler's laws, see: http://astro.unl.edu/naap/pos/pos_background1.html Use media to discuss collisions, particularly simulations of colliding objects.
HS-ESS2.B, Plate Tectonics and Large-Scale System Interactions: Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history.	The "Plate Tectonics" Augmented Lesson (estimated release January 2019) will address this topic in detail, via Science on a Sphere plate tectonics data sets.

HS-PS3.D, Energy in Chemical Processes and Everyday Life: Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation.	Discuss nuclear fusion and stellar evolution. Use media to highlight key steps/processes. Discuss the various types of radiation using an image of the electromagnetic spectrum, and if possible, review instruments/missions that use each type of radiation. See the “How Do We Know?” lesson for ideas on studying other wavelengths.
HS-PS4.B, Electromagnetic Radiation: Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities.	Discuss spectroscopy, using gas tubes and diffraction gratings, if possible (as above).
HS-ESS2.A, Earth Materials and Systems: Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth’s surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth’s interior and gravitational movement of denser materials toward the interior.	The “Plate Tectonics” Augmented Lesson (estimated release January 2019) will address this topic in detail, via Science on a Sphere plate tectonics data sets.