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**The Universe: Its Full of Stars!**

**Unit Title**: Star Stuff

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**Introduction**

William Penn High School is a public high school in the Colonial School District in New Castle County, DE. It is the only high school in the district and it is the largest high school in the state of Delaware, serving approximately 2,200 students grades 9-12. The school district is mostly suburban, with small portions of the district being considered urban (the far northern portion of the district pulls from southern Wilmington) and some being considered rural (the far southern portion of the district pulls from farmland situated on either side of the Chesapeake and Delaware Canal. In total, the district serves over 10,000 students and expects to increase in size as the New Castle area experiences is revitalized by industry and job growth.

In order to make every student college and career ready, William Penn High School is divided in three college academies: the STEM College Academy, the Humanities College Academy, and the Business College Academy. Each college offers majors, or pathways of study. Incoming students decide on a pathway of study and must earn three consecutive credits related to that pathway as a requirement for graduation. However, there is still a strong emphasis on core subjects such as Math, English Language Arts, Social Studies, and Science. Chemistry, the course for which this unit is written, is offered as a third science credit for students who have mastered Science I and Biology and show a proficiency in Math. Most of my students are college-bound Juniors enrolled in the STEM College Academy, although in recent years the number of Humanities and Business students has increased.

**Rationale**

One of the first major concepts that students are introduced to in Chemistry is the Periodic Table of the Elements. Typically, we just jump right into the layout, format, and mechanics of the table without regard for where these elements came from. This comes back to trouble students later in the year when we discuss nuclear chemistry and applications of chemistry (specifically using the phenomenon of spectral lines to identify elements). Additionally, this unit does not involve the flashy labs that students typically associate with Chemistry. This tends to negatively impact student interest in the topic and engagement in the lessons. But there is an incredible cosmic back story to where all of these elements came from that I can use to build student interest in Chemistry and keep them engaged in the classroom. I will use the cosmic origin of elements along with three-dimensional Next Generation Science Standards (NGSS) instructional techniques to provide students with an authentic and exciting learning experience that can be drawn upon further into the school year. We will start with the following quote from astrophysicist Carl Sagan: “The nitrogen in our DNA, the calcium in our teeth, the iron in our blood, the carbon in our apple pies, were made in the interiors of collapsing stars. We are made of star stuff.” To me this is one of the most fascinating statements I have ever heard, and I hope to anchor this unit around it.

**Objectives**

There are several course objectives and aspects of NGSS that I will address in this unit. Specific to the course, students will learn that: (1) light elements such as Hydrogen and Helium originated in the Big Bang some fourteen billion years ago, (2) Heavier elements such as iron and gold didn’t come about until much later when stars progressed through their lifetimes and fused lighter elements together, and (3) spectral lines can be used to identify what kinds of elements are present in distant stars. These objectives will be met through three-dimensional NGSS instruction that includes the following Science and Engineering Practices (SEPs): obtaining, evaluating, and communicating information, developing and using models, constructing explanations, and engaging in argument from evidence. I will also use the following Cross-Cutting Concepts (XCCs) to structure information in the classroom and to set a purpose for learning: patterns, scale, and energy and matter. In order to supplement learning in this unit, students will use spectroscopes, gas lamps, and a newly renovated state-of-the-art planetarium.

These strategies will lead students to mastery of the following Disciplinary Core Ideas (DCIs): HS-ESS1-3: Communicate ideas about the way stars, over their life cycle, produce elements (emphasis is on the way nucleosynthesis varies as a function of the mass of the star and the stage of its lifetime and thus produces different elements), HS-PS1-8: Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay (emphasis is on simple qualitative models that convey the scale of energy released in nuclear processes), and HS-ESS1-1: Develop a model based on evidence to illustrate the life span of the sun and the role and nuclear fusion in the core to release energy (emphasis is on the energy transfer mechanisms that allow energy created in fusion to reach the earth).

**Key Concepts**

Students will understand that:

* Atoms are made up of protons, neutrons, and electrons. Each subatomic particle is comprised of different types of quarks, whose origins can be traced to the early stages of the universe.
* The forces that operate on the smallest atomic scale are the same ones we observe on much larger scales.
* The Periodic Table of the Elements is organized in order of increasing atomic number.
* Nuclear fusion is the process by which two or more nuclei collide and create a new element and release energy.
* The Big Bang produced Hydrogen and Helium in the first two minutes after the universe began expanding.
* Light elements were formed in stars in similar in size to our own over the next few billion years, while heavier elements were formed in stars about ten times as massive as our own sun.
* Spectral lines, which exist because electrons move up and down energy discrete energy levels, can be used to identify what elements are present on astronomical bodies.

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