



Metamorphosis: A Biological Process with Human Implications

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This curriculum unit is recommended for:
American History 1 and 2 / 11th and 12th Grade

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Teaching Standards: See [Appendix](#) for teaching standards addressed in this unit.

Synopsis: This unit links human behavior to biology using historical examples drawn from the North Carolina Standard Course of Study for American History I and II. It is designed around 3 instructional segments covering 2 weeks of instructional time. During that time, we will focus on 3 processes which can be applied to a variety of historical examples, namely nation building, colonization and adaptation to the environment. The initial lessons will introduce key biological terms and concepts which will be applied to make comparisons between the biology and history disciplines. Students will debate whether a political entity can be considered “alive”. This will be followed by an analysis of colonization efforts by several European nations. The unit will conclude with an analysis of Prof. Turner’s *Frontier Thesis* and ask students to debate whether the character of the United States has metamorphosed over its history to become a more rugged, individualistic nation thanks to its interaction with a receding frontier.

I plan to teach this unit during the 2014/2015 school year with my students in my American history classes.

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Alan Vitale

“Different sorts of survival machines appear very varied on the outside and in their internal organs. An octopus is nothing like a mouse, and both are quite different from an oak tree. Yet in their fundamental chemistry they are rather uniform, and, in particular, the replicators that they bear, the genes, are basically the same kind of molecule in all of us—from bacteria to elephants. We are all survival machines for the same kind of replicator—molecules called DNA— but there are many different ways of making a living in the world, and the replicators have built a vast range of machines to exploit them. A monkey is a machine that preserves genes up trees, a fish is a machine that preserves genes in the water; there is even a small worm that preserves genes in German beer mats. DNA works in mysterious ways.”

--Richard Dawkins, *The Selfish Gene*

Background

As a passionate student of history, I am continuously reminded that history is interconnected with other academic disciplines in surprising ways. Famous events and historical periods can often be best explained using concepts taken from other academic fields. For example, the Middle Ages were defined by the biological processes enabling the rapid spread of the bubonic plague. The economic collapse of the Great Depression is most easily understood using panic theory and human psychology. The intensity of the interactions between urban inhabitants during the Industrial Revolution can be compared to the behavior of charged particles under compression as studied in physics. The emphasis on standardized testing and the pressure to conform to course specific pacing guides leaves many teachers with few options to integrate outside disciplines or vary their approach to teaching. The result is a “drill and kill” approach which emphasizes history as a series of events which seem unconnected or disjointed to our students. Older pacing guides mandate our students learn hundreds of terms, leaving very little time to dig into the subject matter in a meaningful way. Students have commented on the fast pace of the classes and the difficulty they have in keeping up. It is not unusual to hear them complain we only spend two days on World War II, far less than they were hoping for, especially when they have elderly relatives who served in the conflict. By throwing these requirements at our students, we are missing an opportunity to bring history alive, and it does not surprise me that only one out of every six Americans can find major world hotspots like the Ukraine on a world map.¹

We must find ways to expand upon a vocabulary based curriculum punctuated by high stakes testing. The approach often leaves students searching for a “silver bullet” correct answer which can be regurgitated for a grade as opposed to truly understanding

the larger process which sparked the event. History is governed by logical concepts which explain the past and lend insight to the future, yet under the current paradigm, teachers have little time to explore those concepts or connect to other curricula to provide insight as to how historical events fit together.

This past year, all that changed. The state of North Carolina changed the pacing of the US history course, effectively doubling the amount of time we have to teach American History. The course that used to be called United States History was split into two courses and teachers now have two semesters to teach the class, albeit with a bit more material added. With the doubling of available class time, teachers have the perfect opportunity to experiment with new ideas and learning schemes. The added instructional time provides the opportunity to introduce concepts from another curriculum like biology to explain the causes behind historical events. I want my students to imagine nation-states as living organisms whose functions mirror those of smaller biological counterparts. They struggle to survive as would any other organism and comparing a nation-state's actions to biological entities provide a memorable way to understand why nations act. Sadly, we do not have time to investigate the full range of biological actions states may engage in, so in this unit, we will compare specific historical processes like colonization and nation-building to the biological process of metamorphosis to spark student understanding. Students will explore the variety of ways that human behavior parallels the metamorphic behavior of other species and how that behavior translates into successful adaptation practices. The goal is for my students to learn historical events do not happen in isolation. To truly understand history, students must see larger connections, both within the discipline of history and with outside disciplines like biology. The author Michael Crichton captured the dilemma of making these connections when he pointed out “[They] were a leaf that didn't know it was part of a tree.” I want my students to be able to swing from a variety of branches on the tree of knowledge.

Introduction

The overarching theme of the unit as expressed in the opening quote by Richard Dawkins is that humans are “survival engines” and as such, we adopt behaviors that improve our chances of success. Darwin's classic mantra is as true today as it was when he first sailed on the HMS Beagle in 1831. Our species struggles to survive and the choices we make both individually and collectively are aimed at expanding our reach and security. It can be argued the same strategies that allow a species of jellyfish to colonize a new stretch of coastline or seafloor were used by nation-states like England and France to establish colonies on far-flung shores. The decision whether to allocate precious resources to build city walls for defense or till more fields to grow extra food have been made by other species in different ways. My hope is when students see human behaviors as inextricably linked to those of other species, it will foster a sense of inquiry, interconnectedness and understanding of both history and biological metamorphosis models.

A second and equally important benefit to incorporating biological metamorphosis into the analysis of human behavior is the ability to develop real life simulations. Unfortunately, there is difficulty in teaching historical events. They are impossible to duplicate beyond dressing up elderly re-enactors who square off on an ancient battlefield or preserve an old building students can visit on a field trip. Short of a massive CGI budget, there is no easy way by which to bring history alive. That changes by adding a biological comparison to the curriculum. Unlike “dry” readings which merely recount an event, a biological experiment can inject excitement and a sense of reality by recreating colonization, warfare or settlement on a tiny but observable scale. Seen through a microscope, students can predict the outcomes of biological events as they play out in miniature detail, duplicating historical processes which would be difficult to recreate otherwise. Although students cannot reach across time to recreate the settlement of the New World, they can observe a similar process as jellyfish planula and polyps populate a new area the same way ships filled with European colonists might have done at Jamestown, Quebec City or Veracruz. Factors like temperature, food supply and predators which affect their odds of survival also apply to human endeavors. Students who partake in these experiments will leave with a better understand why past events occurred and more importantly, the processes which drove them.

Such creative thinking allows me to show students something tangible. To paraphrase a colleague, theory only takes them so far because theory is just that—theory. Bookwork is only bookwork. While both have their place, my hope is for students to creatively explore the reasons events occur and dissuade them from the belief that mere memorization of events and famous people is all it takes to understand history.

Rationale and Objective

The hands-on approach incorporated in this unit is designed to appeal to high school students like those at East Mecklenburg High School. Our high school serves about 1750 students in grades 9-12. Geographically, “East Meck” is located in Charlotte, NC, the largest city in North Carolina and is part of the Charlotte-Mecklenburg School District, one of the largest in the nation. About 60% of our students are considered economically disadvantaged (Title I). We have a diverse school population which includes approximately 25% white, 50% African-American, 16% Hispanic, 5% Asian, and 4% other students. Less than half of our students were deemed proficient using “READY” standards in 2012-13, showing the need to make gains with a challenging demographic. I teach US History to 11th and 12th graders and World History to 9th graders. Despite the categorization of most of my classes as standard level, the students possess varying academic abilities and backgrounds. To accommodate their needs, I use differentiated activities to reach the greatest number of students in a variety of ways, hoping for the key which unlocks their learning. Given the unit’s target audience of 16 to 19 year old

students and their imminent step into adulthood, it is imperative they develop a sense of the larger world around them.

Teaching students to apply a biological process to interpret past historical events can do just that. It has the added benefit of encouraging my students to think beyond the traditional Euro-centric approach which many of my diverse students do not readily identify with. By drawing parallels between the disciplines of history and biology, students are encouraged to think creatively about why behaviors exhibited in one course of study can be used to predict those in another. I also hope to improve cross-curricular awareness between STEM courses and history classes while incorporating more creativity into my courses. Students will benefit from early exposure to the important historical concept of “change over time” in both disciplines. This cross-curricular teaming is an essential new element encouraged of the new Common Core standards and encourages both horizontal and vertical planning amongst our faculty. It also offers the opportunity to engage students in a dialogue about environmental determinism and adaptation in the face of global change. With climate change, global trade, and energy/water shortages on the horizon, an awareness of adaptive behaviors available to nations like our own can help students think creatively about possible solutions.

We will examine the history of the United States, beginning with the colonization of the New World by England, Spain and France as detailed by the North Carolina Standard Course of Study for American History I and II. The above social studies curricula were drafted by our state’s Department of Instruction and all students must pass an official End of Course test to show mastery. At least a third of my students struggled with the course the prior year with a different teacher so I am looking for a thoughtful approach which challenges them to see history in a different light. I believe the emphasis on biological metamorphosis will afford us the opportunity to dig deeper into concepts of culture and place as we teach the historical events required by the state.

Unit Structure and Content

This unit links human behavior to biology using historical examples drawn from the North Carolina Standard Course of Study for American History I and II. It is designed around 3 instructional segments covering 2 weeks of instructional time. During that time, we will focus primarily on 3 processes which can be applied to a variety of historical examples, namely nation building, colonization and adaptation to the environment. The initial lessons will introduce key biological terms and concepts which will be applied to make comparisons between the biology and history disciplines. Students will debate whether a political entity can be considered “alive”. This will be followed by an analysis of colonization efforts by several European nations. The unit will conclude with an analysis of Prof. Turner’s *Frontier Thesis* and ask students to debate whether the character of the United States has metamorphosed over its history to become a more

rugged, individualistic nation in comparison to the European nations thanks to its interaction with a receding frontier.

As part of my recurrent strategy, the initial classes begin with an introduction of key biological terms and concepts. Establishing a shared nomenclature will help lay a foundation for students to play with the notion that nation-states are similar to living entities. While it may seem like a slow way to begin a cross-curricular unit, the need for developing a shared set of terms (disciplinary literacy) when dealing with complicated concepts is clear. Students must share a common lexicon to communicate, both with each other and with the teacher who is guiding them.

The Nation-State as an Organism

The unit is based upon teaching an analytical model or “scheme” which encourages students to compare the characteristics of political entities to biological organisms. In our analysis, nation-states will be compared to self-contained biological entities capable of acting in their own best interests, just as if a nation were a bacteria, jellyfish or ant queen. I am not contending nation-states are actually living organisms, but merely that their behavior can parallel that of living creatures. Still, the idea of a nation being an actual “super-organism” has been advanced by several eminent philosophers. Oka Asajirō advanced a theory that nation-states are biological macro-organisms capable of uniting a people like the Japanese into a proto-organic entity.² For a short time, his vision seemed supported by the rise of modern Japan during the early part of the twentieth century. He argued the Japanese nation’s individual members could give up their individual will to become a single political-organic entity, similar to an ant hive which shares a common purpose and function. His hypothesis has not held up to historical cross-examination and must be viewed through the lens of Asajiro’s strong sense of Japanese nationalism. Yet it provides an interesting analysis. More modest views comparing nation-states to organisms were advanced by European philosophers. The most influential was Georg Wilhelm Friedrich Hegel, a German philosopher who wrote extensively on the development of systematic approaches to disciplines as diverse as art, religion and statecraft. His *Organic Theory of Statehood* postulates “A nation's religion, its laws, its ethical life, the state of its knowledge, its other particular aptitudes and the industry by which it satisfies its needs, its entire destiny, and the relations with its neighbors in war and peace - all these are extremely closely connected.”³ His theory classifies the nation-state as an animate, organic body and although it has been criticized by notables like Karl Marx,⁴ it still has adherents who admire its precision. Hegel’s theory was further developed by an English philosopher Spencer.

“...Spencer's most vivid image was the "social organism", which likened a society to a biological entity. More complex social organisms displayed greater amounts of internal economic and social differentiation, then: just as plants and animals showed greater levels of internal physiological specialization (that is, dedicating a specific organ or

system to a physiological function such as respiration or circulation), so too would there emerge individual citizens or industries that specialized in a particular social or economic function.”

Social scientists like Spencer admired Hegel’s hypothesis because it provides historians a model which rationalizes motivations behind a state’s actions. Nations are complicated entities but in a competitive environment, they are invariably motivated by self-interest. By studying how natural organisms pursue their own self-interest and comparing it to nations, their actions can be better understood.

While it is unorthodox to link history and biology in the same lesson plan, having a central unifying scheme has long been recognized as important when teaching young adults. As one expert noted, “Student’s minds are not blank slates able to receive instruction in a neutral way.”⁵ When faced with complicated ideas, students have difficulty processing them into their knowledge base without a unifying framework. A student may know details about both the American Revolutionary War and the War of 1812, but they may not understand the relationship between the two events without a unifying link. Without an amalgamating model, they are more likely to assimilate them as unconnected events: “The student does not necessarily see the need for a coherent view, since ad hoc interpretations and predictions about natural [and historical] events may appear to work quite well in practice.” Simply put, students don’t know they are missing an entire web of connections between two events if they get a 100% when tested about each event individually. The introduction of a biological framework like metamorphosis which explains human activity in a logical way gives them a method to pull together a variety of individual facts. This in turn can unify students’ interpretations of historical events, allowing “teaching activities which are more likely to be interpreted by students in the way intended.”

The unifying theory as proposed in this unit is simply expressed: Nation-states are biological organisms capable of undergoing metamorphosis. With the unifying theory chosen, the question of how to introduce the concept to students is paramount. I would recommend a teacher carefully consider their students’ maturity, background knowledge and class temperament in deciding how to tackle this. Given that my 11th and 12th grade students were required to take Biology as a 9th or 10th grade science course under the North Carolina Standard Course of Study⁶, it was assumed they already had a basic understanding of the subject. There may be the unusual student who did not pass Biology in the first two attempts or who transfers in from a district which did not require biology before the 11th grade. Some scaffolding may be necessary for those students if they struggle, but generally speaking, we will not be teaching biology “per se” at a level which makes it unapproachable. I am, after all, a history teacher. To build on the prior knowledge, I asked a well-known biology teacher at our school to join me in planning the first lesson. This cross-curricular cooperation is envisioned in the common core standards and given the possibility of misunderstandings when combining disciplines as

diverse as social studies and science, it makes sense to have a resident expert in both fields present as the lesson is implemented. The biology teacher's presence in my classroom also conveys the importance of understanding biological idioms and ensures clear communication of their meanings to the students. This cross-curricular cooperation is seen as an increasingly important trend in education, especially between sciences and social studies.⁷ In fact, many European countries have already begun experimenting with such combinations, although usually such collaboration takes place in the areas of civics and environmental stewardship. It will be the first attempt for me to partner at a meaningful level and I know that nothing in schools works perfectly the first time, so flexibility is the word of the day.

Is a Nation-State Alive?

In order for students to view nation-states as living organisms, they must first be reminded of what a living organism actually is. I was surprised to learn there were minor variations in the characteristics biologists required to classify a living organism but settled upon the lowest common denominator of five factors. For the purposes of our unit, these five key characteristics will define what constitutes a living organism:

- 1) Internal organization,
- 2) Use of energy,
- 3) Ability to respond and adapt to their environment,
- 4) Ability to grow, and
- 5) Reproduction.⁸

The basic definitions we use are important because communication must be absolutely clear when translating between subject areas. A common core writer noted: "Vocabulary plays an even more important role in understanding nonfiction and informational text. It has been estimated that 80% of comprehension in nonfiction is dependent upon understanding that vocabulary". That may involve making trade-offs between technical specificity and common understanding when it comes to the words we use. For example, "evolution" is more accurately described as "descent with modification". When Charles Darwin first wrote *The Origin of Species*, he used the latter term to describe the evolutionary process.⁹ He meant that populations accumulate differences over time as genetic material known as alleles mutate in some individuals within a group. Although the individual with the new genetic variations differs from its ancestors, it still retains the majority of the characteristics possessed by those same ancestors. Hence, when evolution occurs, both descent (shared ancestry) and modification are at work at once. Although "descent with modification" is technically accurate, there is no need to pursue that level of specificity given the constraints of time and the student's attention. Using it would likely complicate the larger mission of the unit. Students are more likely to be familiar with terms such as "fitness" and "survival of the fittest." Darwin's most significant contribution was the Theory of Natural Selection – which states that if there is a selective

pressure (environmental, lack of food, disease, etc.), those organisms with certain genetic traits that can survive and reproduce have increased fitness and a greater likelihood of survival; organisms who lack sufficient genetic variation to adapt will be less fit leading to declining populations and potentially extinction. A second reason for choosing the 5 factors listed above is the ease by which they can be applied to our analysis of modern nation-states. For example, every nation possesses some form of government, whether Communist, Socialist, Republic, etc.

Internal Organization

The first requirement that a nation possesses “internal organization” to qualify as a living organism does not require a big intuitive leap for students as it seems relatively obvious to most. Still, the level of detail in the analysis can be scaled to match the level of student. For example, internal organization can be described as the mere presence of a national governmental body by some students. Conversely, advanced students could be asked to research the structure of government itself, focusing on critical subsystems such as a national transportation network that functions as a circulatory system.

Use of Energy

The second criteria, “use of energy” can be a bit more tenuous to make. The concept may be made clearer by describing “use of energy” as either production of food or power. Food provides a clear cut analogy as every nation must feed itself as surely as a living organism must sustain itself. This would be an appropriate time to note there are differing levels of efficiency in food production which give one nation an advantage over another. For example, the United States is currently the most productive overall agricultural producer in the world.¹⁰ Given its large average farm size, excellent transportation network and ready access to crop inputs, its cost per acre is among the lowest in the world and its output among the highest. Food prices are the lowest in the world, giving Americans an economic advantage over competitors. Small farmers in marginal economies do not share the same advantages and may pay many times more to produce the same quantity of food/hectare.¹¹ Food also directly impacts energy use in a given nation. According to the United Nations, 21% of all fossil fuels used by humans are consumed by the global food system, either to power machinery, create soil inputs, or fuel transportation systems.¹²

Given time, the use of energy (as a fuel/power source) can be further explored to reveal some surprising conclusions about the viability of nation-states. In nature, production efficiency (energy use) is closely related to the morphology (size and shape) of the organism. Endotherms are creatures which maintain a constant body temperature and much of their food/energy use is tied to maintaining heat. Humans are endotherms and most students will readily identify with the concept. What may surprise them is how little energy endotherms have remaining after temperature regulation for growth, reproduction or defense. Their internal energy requirements account for almost all the

energy they generate. Body size and shape is also important to how a nation-state or organism processes the energy it has. Endotherms with greater body mass and less attenuated shapes have an ability to conserve energy thanks to lower surface to area volumes ratios and more efficient circulatory systems.¹³ This concept can be applied to nation-states as well. Large nations with contiguous borders like Spain and France were better able to enjoy economy of scale advantages while smaller nations like the Netherlands and Sweden were unable to compete as efficiently over the long-term. If a nation-states reproduces through colonies, there is a clear advantage to larger, cohesive organisms like England, France and Spain who have the extra “energy” to fund the costly venture of establishing new bases. The failed attempts of the Dutch at New Netherlands and Recife, Brazil and the Swedes at New Sweden confirm smaller political units operate at a competitive disadvantage.¹⁴ They simply do not have the surplus energy to match the colonization efforts of larger rivals.

Another related avenue of analysis is the role of energy/food production in creating conflicts and escalating tensions between both nations-states and living organisms. The expansive rolling plains and accompanying grain production of the Ukraine may be part of the reason for Russia’s predatory interest in that besieged nation today.¹⁵ Either way, the factor opens a myriad of exploratory discussion possibilities.

Ability to Respond to Environment

The third factor in defining nation-states as living organisms centers upon a nation’s ability to respond to its environment. This can be demonstrated in a multitude of ways using both biological and political examples and may invite a live demonstration to heighten student interest. Biologists have long noted the ability of biological organisms to respond to a host of factors including competition, predation, temperature, salinity, food scarcity, and pH.¹⁶ Examples are too numerous to mention although a list has been added to the appendix and several notable examples follow: English botanist A.G. Tansley’s famous experiments with straw plants demonstrated how species compete with each other for available space.¹⁷ J. Connell found *Semibalanus* barnacles colonized where they were less susceptible to desiccation (drying out).¹⁸ Ocean temperature rise has been found to cause bleaching in coral reefs across the globe by forcing the zooxanthellae that reside inside the coral to depart and triggering species migration.¹⁹ Students are living organisms themselves and can easily brainstorm a multitude of ways the environment forces them to modify their behavior. Asking them to come up with a list of such environmental stimuli would be easy for most and could provide an excellent introduction. It could also make a sound segue leading to the behavior of nations when confronted by environmental obstacles or opportunities.

Ability to Grow

The fourth factor in deciding if a nation behaves as an organism centers upon its ability to grow. Growth can be defined as either an expansion in a nation’s borders or an increase

in the size of a nation's economy or population. An enlargement in the physical size of the United States can be best exemplified with the addition of new territory acquired between 1803 and 1898. During that time period, the US acquired a succession of new territories including the Louisiana Purchase, Florida, Texas, Oregon, the Mexican Cession, Gadsden Purchase and Alaska, more than tripling the size of the young nation. Proving physical expansion for more stable nation-states like Belgium or Luxembourg who have not seen little variation in their borders may be more challenging.²⁰ Hence, it may be best to present growth in the form of economic or population increases. Most nations experienced economic and population growth over the course of their histories, and census data can provide ready access to track those changes. The United Nations estimates that over 213 nations have Census data, accounting for over 93% of the world's population.²¹ In the United States, detailed census data have been collected in 10 year intervals starting in 1790.²² Given the ready access to global census data, proving growth should not be difficult. Interestingly, the set of metrics students select to measure growth may result in differing outcomes. While economic and population data for the United States have increased every decade since our first census, the United States' borders have remained static since the addition of Hawaii in 1959.²³ That may lead to differing conclusions about whether the United States possesses the characteristics of a "mature" organism or an adolescent one.

Ability to Replicate

The final factor used in our analysis focuses on a nation's ability to replicate. This is probably the most difficult of the 5 steps in which to make a direct comparison as nations do not have offspring in the traditional sense. Hence, drawing a correlation between political and biological entities requires a more attenuated line of reasoning. Although it can be argued a nation-state can reproduce elements of itself like its culture or economic system in other locations, I would argue the colonization process provides the simplest narrative to illustrate that a nation is capable of reproduction. Colonies allow the parent nation to replicate its political, cultural and economic institutions on a distant shore, paralleling the reproduction of animals like the jellyfish, barnacle and bivalves. The inhabitants of the Spanish colonies in the New World inherited the language, religion, currency, and social structure of Spain, just as the above species inherit their parent's genetic information.²⁴ The same was true for the English settlers in the 13 American colonies and the French colonists at Quebec and Acadia. Given those examples, creating colonies provides a viable way to pass on a nation's characteristics to a new area and likely satisfies the reproduction requirement in our analysis.

Once the biology teacher has introduced key characteristics, we will investigate how they can be applied to a variety of organisms. These characteristics are easily applied to political entities with a little creativity on the part of the students. As teachers, it will be important to encourage creativity and some risk-taking during this unit. Possible teaching strategies which further risk-taking could include modeling risk-taking connections, using

peer based learning, or creating low entry thresholds during brainstorming discussions. Regardless of what methods are adopted, remember there are few right or wrong answers. Students must be encouraged to think about these definitions and processes for themselves. The esoteric nature of these comparisons may seem difficult at first but even the most hesitant students will probably come to similar conclusions with some coaxing. Among those conclusions will be that nation-states can be compared to living organisms and agreement over the criteria used to make that analogy. This realization leads to the next step in our unit: analyzing how the life history strategies of various nations affected their success or failure.

Examples of Colonization as Metamorphosis

Once students have become comfortable with the idea of using a biological model to analyze nation-states functions, the unit's focus shifts to the colonization process in the New World by major European powers during the Age of Exploration. This era is often misunderstood by students who remember little beyond Columbus' first voyage of discovery in 1492. They often have difficulty recalling the various nations involved and rarely differentiate between the colonization methods used by the French, Spanish and English. This seems surprising given that each nation's approach was radically different and led to distinctly different outcomes. Specifically, the Spanish often looked to colonize with brute force, the French through symbiosis with local inhabitants, and the English with mass dispersal which eradicated native opposition.

The colonization efforts of England, France and Spain all required strong political units capable of mobilizing substantial men and material. Understanding the differences between each nation-states and the strategies they pursued will help students recognize there are a variety of ways to pursue colonization. Portugal would make an excellent introductory example as it possessed a strong, centralized political structure, expanded abroad during the late 15th and 16th centuries, and served as the catalyst to the colonization efforts of England, France and Spain.

The Age of Exploration may be viewed as a migration in search of new resources. It was prompted by Muslim invaders who severed European trade routes with the Far East in 1453 when they sacked Constantinople. The desire for valuable trade goods like spices and silks encouraged nations like Portugal and Spain to attempt voyages of exploration abroad. Because Europe at that time was divided into a patchwork of competing nation-states with little in common beyond each nation's self-interest, there was no effort at cooperation between them. This created an environment found in virtually every ecosystem where competition between organisms results in each organism attempting to maximize its chances of survival at the expense of the others. The nations which initially invested in exploration did so either to gain a competitive advantage over competing nations or because they were prevented from expanding in other, more traditional ways. Portugal is instructive of this. It originated as a small nation-state located on the Western edge of the Iberian Peninsula. The Portuguese gradually

overcame foreign (Moorish) control and gained independence from neighboring Castille by 1385. Despite their relatively poverty and small population, they pioneered in European exploration and colonization. Ironically, Portugal's small size and isolated location within the European "ecosystem" may have been what led it to undertake colonization in the first place. Just as the *Apis mellifera* European Honeybee will divide and swarm when its existing resources become inadequate, the Portuguese had to venture westward into the Atlantic Ocean as their only avenue of expansion. Everywhere else in Europe was blocked by competing nation-states like the newly unified Spanish monarchy under Ferdinand and Isabella. The Spanish were quick to demonstrate how one nation-state will adapt the behaviors of its neighbors to take advantage of new discoveries as they hired Columbus for their own voyage of exploration.

For the lesson on colonization, we will introduce the Spanish, English and French colonization models and link each to a species which utilizes metamorphosis to help explain their success using biological exemplars. The Spanish were the first to make inroads in the New World, and we will examine them as our first comparison. Although the Spanish colonized several Caribbean islands like Hispaniola as bases of operation before 1519, the native inhabitants like the Taino Indians provided little opposition due to their small numbers and susceptibility to Spanish diseases. The greatest Spanish achievements came after they reached the mainland where their colonization efforts yielded unimagined success. In 1519, Hernan Cortez arrived at Tenochtitlan, the nerve center of the Aztec Empire. With only a few hundred men, he was able to overwhelm a complex civilization numbering in the millions. Although disease played an important role, it is hard to imagine how so few Spaniards could conquer so many Aztecs. Historians have long speculated why the Aztec king, Montezuma II, did not outright kill the Spanish invaders when he had a chance. It would have been easy given that the Aztec army numbered over a quarter of a million soldiers.

Part of the answer may lie in examining the behavior of the *Wasmannia auropunctata* fire ant and applying the results to the Conquistadores. A 2007 study found that a colonizing species' success may result from a native species initially failing to recognize the threat posed by the invader. To prove this, scientists observed two species of ants, the aggressive *Wasmannia auropunctata* and the more docile *Pheidole*. Both species were native to French Guiana where the two species maintained a balance. This balance existed because aggressive *auropunctata* incursions were intercepted by large numbers of *Pheidole* "major workers" who mobilized to stop *auropunctata* soldiers from infiltrating *Pheidole* controlled food sources. The *Pheidole* "major workers" were the only *Pheidole* ants possessing the physical size to kill the *auropunctata* invaders. Hence it was absolutely crucial these "major workers" coordinated their efforts to repulse the invaders. In French Guiana, the coordinated response of the more docile *Pheidole* proved highly effective in defending against *auropunctata* attacks. However, on a different island like New Caledonia where the *Pheidole* species existed without competition, an experimental introduction of *auropunctata* failed to elicit a coordinated response from

the *Pheidole* species. Simply put, the more docile ant tribe was unused to defending itself and had no protocols in place to alert its major workers. Unsurprisingly, this led to a sharp decline in the number of *Pheidole* population when two species had no prior interaction. The more docile *Pheidole* species, like the Aztecs, lacked the ability to immediately recognize the danger represented by the invaders and did not form a coherent defensive strategy until too late. In the words of the study's authors: "This factor could explain how invasive animal species, particularly ants, may be able to successfully invade species-rich communities."

Such behavior may help explain why the Aztec king did not initially recognize the Spanish invaders for the threat they represented. That this mistake was made not only by the Aztecs but the powerful Incan Empire a few years later is more than just coincidence. Both native civilizations failed to recognize the invasive threat and consequently, failed to mobilize to meet it in an effective way.

The history of the French colonization in the New World had a very different outcome. A small number of French colonizers initially sought material wealth and access to the Far East by colonizing North America. Unlike the massive treasures found in Central and South America by the Spanish, the French found no high value inputs and consequently could not finance rapid, high energy colonization efforts as the Spanish could. Hence, the French opted for a slower, more deliberate colonization model which established a symbiotic relationship with local Native American tribes like the Huron and Algonquin. Given the extreme cold of the Canadian winter coupled with the short growing season, agricultural production was not a viable option as it was for the English colonies. Lacking other options, the French were eventually forced to rely exclusively on a closely knit fur trading network with the Native Americans, and were dependent upon profits obtained from the partnership to sustain their colony. Given the small scale of the enterprise, the French colonies in Quebec remained small affairs with few European inhabitants.²⁵ Thus, the French depended to greater degree on maintaining close relations with native tribes than either the English or Spanish.

A biological model which mimics the French settlement experience can be found in the corals of the Great Barrier Reef. The *Scleractinian* coral species there are dependent upon mass spawning events for reproduction.²⁶ During these events, the parent coral organism spews clouds of gametes into the ocean where each gamete hopes to externally mix with others. The fertilized individuals then disperse over the reef surface where they attempt to attach to a fixed surface and metamorphose into polyps. Researchers have found the success rate of the *Scleractinian* larvae in achieving metamorphosis is tied to a symbiotic partnership with calcareous coralline algae (CCA).²⁷ The algae forms a biofilm on the reef surface that helps the larvae attach firmly enough to permit further development. Without a 2 week old film, the coral larvae have less than a 10% chance of surviving to metamorphose.²⁸ To return to our comparison, the *Scleractinian* larvae acts much like the French colonists did, searching for a viable surface to land upon. Once

there, they were dependent upon a pre-existing Native American network to sustain them with the profits they needed to survive. The natives who traded with the French colonists acted like the algae, providing the French with a stable network within which they could embed and develop. Without the fur trading natives to provide them with the profits to sustain their colony, the French effort would become unsustainable. Historically speaking, this model helps explain why the French remained absolutely dependent upon the Native Americans until their final expulsion from North America in 1763 under the terms of the Treaty of Paris.²⁹

The English provided a third biological model for interpreting colonization. Although among the last nations to join in the hunt for colonies, English efforts proved to be the most successful at long term colonization. The work of English writer Richard Hakluyt in *A Discourse Concerning Western Planting* gives some insight into their motivations.³⁰ He listed 23 reasons for establishing colonies in the New World, including competition with Spain and as a settlement ground for English workers. Finding an outlet for dissatisfied English workers was important. England suffered from high poverty and social displacement following the enclosure movement and its North American colonies provided a needed outlet to export troublesome elements of society. England lagged behind other nations and given a population half that of Spain and a quarter that of France, England had to develop a colonial model that would resist the predation by larger nation-states. Although population densities in North America were low in comparison to Central America, it was still occupied by native tribes. Given the negative connotations of the Black Legend which accompanied Spanish rule, the English were reluctant to conquer as the Spanish had. Instead, they sought to displace Native Americans and utilize their land for themselves. Instead of intermarrying as the Spanish and French had done, the English colonized in higher numbers and brought their wives and children, leading to high fertility rates among the colonists. Within a short period of time between 1607 and 1640, the English colonial population in North America had exceeded the size of all its European counterparts combined. By 1676, their numbers had supplanted the Native Americans along the eastern coastline.

A biological example that mimics the behavior of the English colonists can be found in example of the tunicate, *Botrylloides violaceus* or “Sea Squirt”. This tunicate has become one of the most persistent invasive species in North America waters. Although the Sea Squirt itself is stationary, it generates huge numbers of larvae after exchanging gametes with neighbors. It then releases the planktonic larvae through aquatic dispersal where they accumulate on available surfaces. The larvae do not live long, but thanks to metamorphosis providing a break in the life cycle, colonies or even partial colonies can survive “indefinitely, reproducing asexually while drifting, or traveling within ship ballast water to colonize new areas.”³¹ The Sea Squirt’s fecundity can be overwhelming to other stationary organisms. It reproduces in such numbers that it is virtually impossible for North American native organisms to compete. It generates problems similar to those of the Zebra Mussel, another invasive species found in the Great Lakes of North

America.³² The tunicate demonstrates the English colonists' greatest strength: their high fertility rate.³³ They arrived in such numbers and reproduced so quickly they simply overwhelmed a weakened native population already decimated by diseases like Smallpox.

By briefly studying the metamorphic process of 3 different organisms which best exemplify each nation's methods, students will be able to understand the strategy adopted by each nation and more importantly, why each nation succeeded or failed in its colonization endeavors. They will also leave with an awareness of the biological concepts linked to metamorphosis and the advantages it confers on them.

Frederick Jackson Turner's *Frontier Thesis* and the Metamorphosis of American Identity

During the final section of the unit, students will analyze the growth of the United States as a nation-state using the influential *Frontier Thesis* as a point of reference and discussion. Since its introduction in 1893, this seminal work shaped the way American history was taught at every level of American education.³⁴ Written by the famous historian Frederick Jackson Turner, the *Frontier Thesis* argued the American state underwent an evolutionary transformation over its 400 year history. The catalyst for our transformation was contact with a wild and unregulated frontier. Turner was a believer in evolution and argued the character of the nation had changed over time. He viewed the first American settlers as European in manner, language and custom. After landing in America, they confronted environmental challenges different from anything they had encountered in Europe. Most important to the new identity was the discovery of unlimited quantities of raw land which had to be carved from an untamed wilderness peopled by savages and wild animals. In the process of adapting to their new surroundings and taming the land, the inhabitants underwent a metamorphic change, becoming a new and unique people known as Americans. The new American identity was rugged and individualistic and steadily diverged from European norms. As each new generation moved further westward, Americans pushed back the frontier line of settlement and underwent a greater change. During this metamorphosis, unneeded European characteristics disappeared much as a butterfly sheds its chrysalis. Old European institutions like the Anglican Church and notions of nobility were steadily replaced by American democracy and native born institutions:

“We have the familiar phenomenon of the evolution of institutions such as the rise of representative government; the differentiation of simple colonial governments into complex organs; the progress from primitive industrial society, without division of labor, up to manufacturing civilization.”³⁵ Turner argued the very temperament of Americans had changed as a result of the process. We became quick to anger and willing to use violence as necessary. We were less concerned with academics and theory than our European ancestors:

“American democracy was born of no theorist's dream; it was not carried in the *Susan Constant* to Virginia, nor in the *Mayflower* to Plymouth. It came out of the American forest, and it gained new strength each time it touched a new frontier. Not the Constitution, but free land and an abundance of natural resources open to a fit people, made the democratic type of society in America for three centuries...”

Using the *Frontier Thesis* as a starting point, students will utilize the concepts we learned in prior lessons to analyze the accuracy of the hypothesis Turner advanced. Equal attention will be paid to its critics, notably the claim that he overlooked the contributions of women and other minorities in his analysis. Other primary source documents can be added for inclusion in the analysis including James Gast's allegorical painting, “*American Progress*”. I plan to conclude with a student debate using a “fishbowl” protocol to govern their discussion. Depending on the maturity level of the class, a different protocol could be adopted. A benefit of the discussion format is that it encourages students to voice their opinions in an unfettered manner but avoids direct conflict between any pair of students.

Strategies and Activities

Lesson Plans #1 - 2 *Are nation-states alive? (How does a country resemble a living organism?)*

Key Question: Can human nation-states be compared to biological organisms? If so, can their behaviors be predicted by modeling biological processes like metamorphosis?

Lesson Goals: 1) Students should be able to identify the key characteristics of biological organisms. 2) Students will be able to compare the behaviors of biological organisms to those of nation states 3) Students will become familiar with the process of metamorphosis. 4) Students will analyze whether metamorphosis can be applied to a nation-state model

Homework: Using examples given out in class, students will analyze a historical nation-state during a specific time period for behaviors which can be compared to a biological model.

Teaching strategies: Cross-disciplinary lecture and presentation, discussion debrief, group and independent research, predictive modeling activity.

Narrative: The lesson plan begins with the need for students to start with a common set of terms which address the lesson goals. In order for students to compare nation-states as living organisms, they will first review the five characteristics which define a living organism:

- 1) Internal organization,
- 2) Use of energy,
- 3) Ability to respond and adapt to their environment,
- 4) Ability to grow, and
- 5) Reproduction .

The cross-curricular cooperation with a biology teacher ensures both the biological and historical lexicon can be explained and ensures clear communication to the students. I envision using an LCD projector to display video of biological functions as we review the enumerated factors. Following the introductory comparison, we will further develop whether political entities can be considered “alive”. We will proceed by splitting the class into groups of 3-4 students to read and discuss several documents. Among them will be the Encyclopedia entry for the word organism, an excerpt of the writings of Otto Von Bismarck, the German Statesman who unified Germany, Richard Hakluyt, "*A Discourse Concerning Western Planting*", Capt. John Smith's "*General Historie of Virginia, New England, and the Summer Isles*", and a Cincinnati Enquirer article debating whether the Constitution is a Living Document. The students will then complete a Venn Diagram as a team and answer the question based on the readings and their own opinions. The point of the activity will be to encourage students to debate the concept of what constitutes a living organism and encourage them to expand its traditional definition to fit a broader definition using the factors we introduced above.

In the follow-up to the first meeting, I will introduce the concept of metamorphosis. Students will begin with a formal definition of metamorphosis before analyzing a series of life strategy choices all metamorphosing organisms must make to survive. Each group and students will then be asked to justify to their peers whether they think a nation-state “organism” is capable of undergoing metamorphosis. After the discussion phase, we will analyze the process of metamorphosis as a class, possibly again in conjunction with a biology teacher who co-teaches the segment. Students will focus on the concept of natural selection as demonstrated through metamorphosis. Metamorphosis is a biological process wherein the organism undergoes a change in form - from a larval form to an adult form. A guideline for introducing it in the context of nation-states follows:

Pre-metamorphosis decisions:

- 1) How fast to grow? (trade, population, environment, competitive species)
- 2) How to develop? (environment, “parent” society’s influences,
- 3) When to metamorphose?
- 4) Where to metamorphose

Post-metamorphosis decisions:

- 5) How fast to begin growing again?
- 6) How large to grow?
- 7) When to begin reproducing (spreading into new cities, colonies, units)?

- 8) What form the new units will take?
- 9) Will the parents or existing constituents support the new units or not?

By analyzing how a nation-state might answer these questions and contrasting it with the choices made by competitors, students gain insight into the strategies a nation can pursue which yield the greatest chances of success. This in turn helps them explain historical outcomes. Once students have become familiar with both the biological terminology and processes, the unit will shift to lessons exploring European colonization during the Age of Exploration.

Lesson Plans #3 - 5 Colonization and Metamorphosis

Key Question: Do nation-states behave like organisms when colonizing new regions? Can metamorphosis explain biological outcomes?

Lesson Goals: 1) Students should identify the key European nations responsible for colonizing the New World. 2) Students will understand the methods adopted by each nation 3) Students should understand how the strategy for each nation contributed to its success. 4) Students will analyze whether metamorphosis confers an advantage during the colonization process.

Homework: Students will research the colonial activities and settlement patterns of a selected European nation who participated in the colonization of North America. Students will be required to make a poster summarizing their nation's colonial history.

Teaching strategies: Multimedia presentation, group discussion with debrief, group and independent research, predictive modeling activity.

Narrative: For the next class segment, students will be asked to consider the colonization process in the New World during the Age of Exploration from both a historical and biological perspective. Students will begin each class in this segment by analyzing a prominent colonizing nation-state. We will begin with Spain, investigating the success of the Conquistadores, the collapse of the Aztec and Incan Empires, and the formation of the Black Legend based on the use of the encomienda system. A biological parallel with a metamorphosing species of fire ants will round out the analysis while providing insight into how so few Spaniards could defeat so many natives.

The next lesson focuses on the French colonization efforts at Quebec. Special attention will be given to the symbiotic relationship the French enjoyed with North American tribes. Students will learn about the fur trade and its effects on native population and power distribution. The class will discuss how the sparse natural resources and cold climate of the area may have shaped the development of the French colonies. Lastly they will compare the French colonization efforts to a symbiotic relationship between algae and coral that allows the renewal of coral along the Great Barrier Reef.

The third colonizing nation is perhaps the most influential to American history: England. Given the United States' close connection to England as our parent nation, it is not surprising it has special relevance in an American History class. Students will learn about the factors that prompted English colonization efforts in the New World, namely the enclosure movement and social dislocation emerging from the stirrings of the Industrial Revolution. The English colonies at Roanoke, Jamestown and Massachusetts will be analyzed for their commonalities and differences, noting the haphazard nature of the overall English settlement effort. The character of English settlement will be discussed in detail with a biological comparison to the Sea Squirt's high reproduction rate. Given time and interest, Portugal and the Netherlands can be added as examples. Students can conclude with an activity prompting them to analyze how life history strategies can determine if a colony would flourish or die. History provides examples of European colonies which met both fates, ranging from Roanoke which mysteriously disappeared to Jamestown which eventually matured into Virginia. Their analysis of these examples should include the factors which affect the colony's success, including the temperature, available nutrition, rigidity of the ground, nearby competitors (predators), etc. Students will be asked to determine why several critical colonies including Plymouth, Jamestown, Charleston, Roanoke Island and Port Royal either succeeded or failed.

Lesson Plan# 6 Adaptive Behaviors and Life Strategy Decisions

Key Question: What behaviors improve a settlement's chances of success? Do organisms exhibit similar behaviors?

Lesson Goals: 1) Students should identify which human behaviors improve survival odds.
2) Students will analyze how phenotypic plasticity allows organisms to adapt to environmental threats

Homework: Using the activities discussed in class, students will have to model the optimum survival strategies and energy expenditures by colonists.

Teaching strategies: Lecture and presentation, Group work, predictive modeling activity.

Narrative: The next class will focus on how European colonies in the New World adapted to environmental factors in the same way organisms must adapt to their surroundings through the phenomenon of phenotypic plasticity. In this process, an organism demonstrates an ability to modify its phenotype in response to an environmental change, basically changing its shape or body type to improve its chances of survival. We would begin the class with a brief introduction of phenotypic plasticity and illustrate several species which use it in response to predators. After a brief question and answer session, we will compare the selection process to human behavior. Although it is a common defensive mechanism among both plant and animal species, I believe it can be applied to human settlements which adapted to meet an environmental threat. For example, the class

could discuss how some species utilize longer spines or faster growth to compensate for dangers in the same way humans build defensive walls or conduct more energetic foraging activities when facing dangers. Excellent examples of these survival techniques were exhibited by colonists at Jamestown, Massachusetts Bay, Quebec City and St. Augustine and show they had to adapt to survive. Native American attacks, sparse food resources and the presence of competitors led colonists to make difficult decisions as to how to best improve their chances of surviving. Typical decisions included whether to expend resources by bringing more farmland under cultivation, building walls for defense or establishing positive relations with natives through trade. Each method was tried with varying success by some colonies and students will be presented with a colonial scenario and asked to decide how they would adapt. I would like to develop the energy costs, perhaps measured by calories and let students make the decision as to how they would guide their colony. Once the students have made their selections, we will allow them to try each activity to determine how strenuous the activity is, perhaps by building a cinderblock wall, digging up a section of field or trading away valuable grade points from their class participation grade. This would give them a hands-on approach to better understand there are costs to each survival technique. We would wrap up the class by going over the behaviors at each major colony and discuss its efficacy.

Lesson Plan #7 Has the United States Experienced Metamorphosis?

Key Question: Has the United States Undergone Metamorphosis?

Lesson Goals: 1) Students should understand Professor Turner's *Frontier Thesis*. 2) Students will be able to analyze whether metamorphosis can be applied to a nation-state model

Homework: Using Professor Turner's *Frontier Thesis* as a guide, Students will write their own essay describing whether they think the United States has undergone metamorphosing change over our 400 year history.

Teaching strategies: Lecture and presentation, class debate, Group and independent research, Primary source readings.

Narrative: In this lesson plan modeled after an activity in the National Archives, students will assess historian Frederick Jackson Turner's classic thesis about the influence of the frontier on American identity. We will begin by splitting the class into small groups of students, asking each group to brainstorm how the United States has changed over time from the earliest colonial days to the present era. We will follow by inviting each group to share their conclusions with the class at large. Each group must then read and interpret Turner's thesis for accuracy. Students wrap up with a reflection which summarizes the unit's impact on their understanding of both history and metamorphosis as a tool to help them understand history's outcomes.

Appendix: Implementing Teachers Standards:

The state has recently instituted Common Core standards, and they are scheduled to go into effect this year for the new semester courses of American History I and II. This move has been thrown into doubt by recent legislation passed which directs the state to develop alternative standards, but we have every reason to believe the standards below remain valid for the coming year. The following standards and clarifying objectives are relevant to the seminar topic.

During this unit I plan to address the following 2014 North Carolina Social Studies Standards:

American History Standard AH1.H3

Understand the factors that led to exploration, settlement, movement, and expansion and their impact on United States development over time. (This Standard can be addressed through a study of human settlement patterns like immigration and colonization as discussed in the CU.)

Clarifying Objective AH1.1H3.1

Analyze how economic, political, social, military and religious factors influenced European exploration and American colonial settlement (e.g., Reformation, mercantilism, improvements in navigation technology, colonization, defeat of Spanish Armada, Great Awakening, etc.). (This Standard can be addressed through a study of human activity over early American history, notably by the colonizing nations of England, France and Spain as discussed in the CU.)

Clarifying Objective AH1.1H3.2

Explain how environmental, cultural and economic factors influenced the patterns of migration and settlement within the U.S. before the Civil War (e.g., economic diversity of regions, mercantilism, cash crops, triangular trade, ethnic diversity, Native American Indian beliefs about land ownership, Lewis & Clark expedition, farming, Industrial Revolution, etc.). (This Standard can be addressed through the colonization process and the obstacles which confronted early settlers as discussed in the CU.)

American History Standard AH1.H.8

Understand how and why the role of the United States in the world has changed over time. (This Standard can be addressed through a study of the taming of the frontier over the course of American History leading up to the 1890 census as discussed in the CU.)

Teacher and Student Resources and Bibliography:

Calder, Lendol. "Uncoverage: Toward a Signature Pedagogy of the History Survey" *The Journal of American History* 92, no. 4 (2006) 1358-1370

This piece focuses on how students learn best by suggesting three pedagogical changes. The first allows students to ask questions that solve personal misunderstandings. These misconceptions can get in the way of student learning and having a safe way for them to address it changes classroom dynamics. The author also suggests the need to collaborate frequently and with establish routines to guide the learning process.

Cappucino, N and P.W. Price, eds. 1995 *Population Dynamics: New Approaches and Synthesis*. Academic Press, New York.

This collection of papers helped illustrate the various approaches to interpreting human population growth via comparisons with those of other species.

Rogers, Spencer et al. *Motivation & Learning*. CO; Peak Learning Systems, 1999

This text is the classic handbook for the PEAK teaching style. It was widely used in our district after 2000 and I love the hands on methods the author recommends to ensure student learning. In particular, it incorporates activities that allow movement, discussion and exchange of ideas but using well understood classroom routines which enable structured learning.

Darwin, C 1859 *On the Origin of Species by Means of Natural Selection*. John Murray, London.

This is the original text that introduced "Evolution". It remains a must read for anyone who discusses the topic.

Gause, G.F. 1934. *The Struggle for Existence*. Williams & Wilkens, Baltimore, MD.

This manageable text encourages using experiments to test ideas about how species contend with their environment, predators and evolution.

Lambers, H., F.S. Chapin III and T.L. Pons.1998 *Plant Physiological Ecology*. Springer, New York.

This work provides insights into the variety of ways plants adapt to the environment, enabling them to thrive in a wide variety of climates.

Pimm, S.L. 2002. *Food Webs*. Univ. of Chicago Press, Chicago.

Although I am no expert in biology, this introductory text helped me grasp the terminology and concepts I needed to draw intelligent comparisons between animal and human food web regimes.

Wilson, D.S. 2007 *Evolution for Everyone: how Darwin's Theory Can Change the Way We Think about Our Lives*. Delacorte Press, New York

This book provides countless comparisons between evolution in the plant and animal world nature and applies them to human behaviors. It is written in an engaging style and offers grist for classroom comparisons between other species and human activity.

Student Resources

Cain, M. L., Bowman, W.D., Hacker, S.D., 2008. *Ecology*. Sinauer, MA.

This ecology text brilliantly introduced the issues addressed above in a readable and colorful manner. Although the text is written at an Advanced Placement level, much of the writing and diagrams can be adapted to fit the classroom lexile level of your 11th and 12th grade students. I particularly liked the extensive use of images to demonstrate complicated concepts which were neatly summarized at the end of each chapter.

Darwin, C 1859. *On the Origin of Species by Means of Natural Selection*. John Murray, London.

This is the original text that introduced “Evolution” as a capital word. It remains a must read for anyone who discusses the topic.

Tindall, G.B., Shi, D.E. 2006. *America, A Narrative History*. W.W. Norton Company, New York.

This history text is also written at an Advanced Placement level but has adopted the unusual approach of a narrative to introduce the history of the United States. Although it still has beautiful full colored maps and detailed diagrams, it is written in a smooth flowing language that appeals to most AP students. I prefer using it for its readable tone and thoughtful commentaries on numerous issues over the course of American History.

Notes

¹ Zeitzoff, Thomas, Kyle Dropp, and Joshua D. Kertzer. "The Less Americans Know about Ukraine's Location, the More They Want U.S. to Intervene." *The Washington Post*. The Washington Post, 7 Apr. 2014. Web. 24 Nov. 2014. <http://www.washingtonpost.com/blogs/monkey-cage/wp/2014/04/07/the-less-americans-know-about-ukraines-location-the-more-they-want-u-s-to-intervene/>. This link highlights the relative ignorance of Americans with regard to global geography.

² Ullivan, G. "Http://www.ncbi.nlm.nih.gov/pubmed/21080039." *PubMed.gov*. NCBI, 16 Mar. 2011. Web. 24 Nov. 2014. <http://www.ncbi.nlm.nih.gov/pubmed/21080039>. (Analysis of Oka Asajiro's theory)

³ Hegel, *Reason in History (LPhWH, 101-2)* (Hegel is the father of the modern nation-state organism theory)

⁴ Marx [1843] in *Karl Marx: Early Writings* (Middlesex: Penguin/New Left Review, 1975), pp. 58-198. Hereafter abbreviated as *Critique*. Hegel's theories drew attention from other controversial critics like Karl Marx who disagreed with Hegel's theories.

⁵ Driver, Rosalind, Edith Guesne, and Andree Tiberghien. *Children's Ideas and the Learning of Science*. Hachette, Paris: Open University Press, 12 June 1983. PDF.pg. 4 (A discussion of pedagogical techniques)

⁶ "North Carolina Standard Course of Study: High School Science Sequences." *Public Schools of North Carolina*. North Carolina Department of Public Instruction, 2004. Web. 24 Nov. 2014. (This site links NC educational standards. Biology is planned as a mandatory 9th or 10th grade class in 4 of the 5 accepted sequences used by the North Carolina Department of Public Instruction.)

⁷ Amadio, Massimo. *Paper Commissioned for the EFA Global Monitoring Report 2013/4, Teaching and Learning: Achieving Quality for All*. N.p.: UNESCO, 2013. PDF. There is a growing emphasis worldwide on the need to equip learners with a set of key competences or essential skills, also defined as '21st century skills', that are necessary to succeed in education."

⁸ Caccese, Vincent. "Characteristics and Classification of Living Organisms." *RQ 21.4* (1982): 421-22. *Cambridge University Press*. Web. 24 Nov. 2014. (A listing of characteristics which define life and how it can be categorized)

¹⁰ United States. Environmental Protection Agency. *U.S. Environmental Protection Agency*. U.S. Environmental Protection Agency, 9 Apr. 2013. Web. 24 Nov. 2014. ("The U.S. farmer is the most productive in the history of the world".)

¹¹ Searchinger, Tim, Craig Hanson, Janet Ranganathan, Brian Lipinski, Richard Waite, Robert Winterbottom, Ayesha Dinshaw, and Ralph Heimlich. *Creating a Sustainable Food Future*. Publication. N.p.: n.p., n.d. World Resources Institute, Dec. 2013. Web. 24 Nov. 2014. <http://www.wri.org/publication/creating-sustainable-food-future-interim-findings>. (Detailed commentary on the future food requirements of human populations)

¹² "Agriculture & Food." *United Nations Environment Programme*. United Nations, n.d. Web. 24 Nov. 2014. (Detailed commentary on the future food requirements of human populations) <http://www.unep.org/resourceefficiency/Home/Business/SectoralActivities/AgricultureFood/tabid/78943/Default.aspx>.

¹³ Angilletta, Michael J., Jr., Brandon S. Cooper, Matthew S. Schuler, and Justin G. Boyles. "The Evolution of Thermal Physiology in Endotherms." (n.d.): n. pag. Department of Biology Indiana State University, Terre Haute. Web. 24 Nov. 2014. <http://angilletta.lab.asu.edu/Publications/Angilletta%20et%20al%20%28in%20press%29.pdf>. A discussion of how an organism's morphology determines its thermal capacities).

¹⁴ Covart, Elizabeth. "New Sweden: A Brief History." *Penn State University Libraries*. Penn State, 11 Oct. 2012. Web. 24 Nov. 2014. https://www.libraries.psu.edu/psul/digital/pahistory/folder_1.html. "Between 1651-1653, New Sweden began to decline. The Swedish government had lost interest in its colony, which was evident as they did not send a single supply ship or any ship, from 1648-1654. Part of this neglect was due to the fact that all of the colony's supply ships, which for the first five years of Printz's governorship came with some regularity, were commandeered by the Swedish government to help in its war against the Netherlands."

¹⁵ "Russia, Ukraine Grain Exports to Flourish Despite Ongoing Crisis." *The Moscow Times*. Ed. Reuters. The Moscow Times, 3 Aug. 2014. Web. 24 Nov. 2014.

<http://www.themoscowtimes.com/business/article/russia-ukraine-grain-exports-to-flourish-despite-ongoing-crisis/504467.html>. ("Russia shocked grain markets with a one-year export ban in 2010 when drought ravaged that year's harvest. The move proved the catalyst for a surge in grain prices and political instability in the heavily import-dependent Middle East and North Africa regions.")

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- ¹⁶ Gause, G.F. 1934b. *The Struggle for Existence*. Williams & Wilkins, Baltimore, MD. (A study noting the effects of environmental determinism on organisms).
- ¹⁷ Tansley AG. 1917. On competition between *Galium saxatile* L. (*C. hercynicum* Weig.) and *Galium sylvestre* Poll (*G. asperum* Schreb.) on different types of soil. *Journal of Ecology* 5, 173-179. (How soil type can affect which species of grass flourishes).
- ¹⁸ Connell, J. (1961). *Effects of competition predation by *Thais lapillus* and other factors on natural populations of the barnacle *Balanus balanoides**. *Ecol. Monogr.* 31: 61-104 (Study of barnacle competition)
- ¹⁹ "Coral Reefs and Climate Change - How Does Climate Change Affect Coral Reefs - Teach Ocean Science." *Teach Ocean Science*. University of Maryland Center for Environmental Science, 2014. Web. 23 Nov. 2014.
http://www.teachoceanscience.net/teaching_resources/education_modules/coral_reefs_and_climate_change/how_does_climate_change_affect_coral_reefs/. (Warmer water temperatures brought on by climate change stress corals because they are very sensitive to changes in temperature. If water temperatures stay higher than usual for many weeks, the zooxanthellae they depend on for some of their food leave their tissue. Without zooxanthellae, corals turn white because zooxanthellae give corals their color. White, unhealthy corals are called bleached. Bleached corals are weak and less able to combat disease.)
- ²⁰ The Nation State, An Essay by Anthony C. Pick, March, 2011 (A discussion of nation-state borders and composition)
- ²¹ "2010 World Population and Housing Census Programme." *United Nations Statistics Division*. United Nations, n.d. Web. 24 Nov. 2014.
http://unstats.un.org/unsd/demographic/sources/census/2010_PHC/default.html. (A link to searchable census information by nation)
- ²² United States. Census Bureau. U.S. Department of Commerce. *Selected Historical Decennial Census Population and Housing Counts*. U.S Department of Commerce, 1990. Web. 24 Nov. 2014.
<https://www.census.gov/population/www/censusdata/hiscendata.html>. (An electronic database with decennial census information.)
- ²³ *Hawaii.gov*. State of Hawaii, n.d. Web. 24 Nov. 2014. <<https://portal.ehawaii.gov/>>. (It can be argued Hawaii was acquired over 100 years ago in 1898 after the Spanish-American War. It was administered by the United States until 1959 when it obtained statehood.)
- ²⁴ "Spanish Colonization." *Digital History*. Digital History, 2014. Web. 24 Nov. 2014.
http://www.digitalhistory.uh.edu/disp_textbook.cfm?smtID=2&psid=3573. (A discussion of Spanish colonial behavior)
- ²⁵ Choquette, Leslie, Ph.D. "Population-Immigration." *Virtual Museum of New France*. Canadian Museum of History, 2014. Web. 24 Nov. 2014. <http://www.historymuseum.ca/virtual-museum-of-new-france/population/immigration/>. (The number of French immigrants numbered less than 3,000 by 1663 and only 19,000 by 1700. Nearby English colonies boasted over 20 times those numbers.)
- ²⁶ Harrison, P. L., and C. C. Wallace. 1990. Reproduction, dispersal and recruitment of scleractinian corals, p. 133-207. *In* Z. Dubinsky (ed.), *Coral reefs. Ecosystems of the world*, vol. 25. Elsevier Science Publishing Company, New York, N.Y (Coral reefs require a symbiotic relationship with other organisms.)
- ²⁷ Johnson, C. R., D. G. Muir, and A.-L. Reysenbach. 1991. Characteristic bacteria associated with the surfaces of coralline algae: a hypotheses for bacterial induction of marine invertebrate larvae. *Mar. Ecol. Prog. Ser.* 74:281-294. (Coral reefs require a symbiotic relationship with other organisms.)
- ²⁸ Metamorphosis of a Scleractinian Coral in Response to Microbial Biofilms, Webster, N.S., Smith, L.D., Heyward, A. J., Watts, E.M., Webb, R.I. Blackall, L.L. Negri, A.P. *Appl. Environ Microbiol.* Feb, 2004; 70(2): 1213-1221. (Coral reefs require a symbiotic relationship with other organisms including marine algae)
- ²⁹ Panay, Andrew. "War, Captivity and the American Civilising Process." *American Studies Resource Centre*. Liverpool John Moores University, 20 Mar. 2014. Web. 24 Nov. 2014.

http://www.americansc.org.uk/Online/Online_2014/Frontier.html. (A discussion of American settlement behavior)

³⁰ "Richard Hakluyt Discourse of Western Planting 1584." *American History From Revolution To Reconstruction and beyond*. University of Groningen, 2012. Web. 24 Nov. 2014.

<http://www.let.rug.nl/usa/documents/before-1600/richard-hakluyt-discourse-of-western-planting-1584.php>. (This document provides early motives behind the English attempts to colonize the New World.)

³¹ http://www.tsusinvasives.org/database/chain_tunicate.html (A United States governmental warning of invasive species)

³² Hebert, P. D. N., C. C. Wilson, M. H. Murdoch, and R. Lazar. 1991. Demography and ecological impacts of the invading mollusc *Dreissena polymorpha*. *Can. J. Zool.* 69:405-409. (The dangers of the Zebra Mussel invading the Great Lakes.)

³³ Lemon, James T. "Colonial America in the Eighteenth Century." In *North America: The Historical Geography of a Changing Continent*, edited by Robert D. Mitchell and Paul A. Groves, 121-146. Totowa, New Jersey: Rowman and Littlefield, 1987. (A discussion of the changing nature of American settlement)

³⁴ It is estimated 60% of colleges modeled their American History curricula on the Frontier Thesis by 1932.

³⁵ Report of the American Historical Association for 1893, 199-227.