

PROPOSED NEW BHS SCIENCE SEQUENCE

9th grade	Physics*		
10th grade	Chemistry*	OR	AP Chemistry*
11th grade	Biology*	OR	AP/IB Biology* Biotechnology 1-2
12th grade	Science Electives** and/or Biotech 3-4		

*Includes topics from Earth/Space Sciences and Science/Engineering Practices (TBD)

**Electives: AP/IB Biology, AP Chemistry, AP Physics, Honors Physics (proposed), AP Environmental Science, IB Environmental Systems and Sustainability, Honors Anatomy & Physiology, Fire Science, Emergency Medical Careers, Sports Medicine

Detailed Analysis and Proposal

1. BHS's Current Science Sequence and Requirements are not aligned with the NGSS

In terms of the content that students will need to learn and the science practices that students will need to master to demonstrate mastery of the NGSS, the BHS science program is currently poorly positioned for success. Here's why.

NGSS at the secondary level requires coverage of four key areas.

- Life Science
- Physical Science (Including what is now covered in "Chemistry" and "Physics")
- Earth Science
- Space Science

In addition to these subjects, new standards related to Engineering are woven through all of the content areas listed above.

Currently, BHS's graduation requirement involves only two years of science: one year of life science (typically Biology), and one year of physical science (which can be met through Chemistry). Despite this requirement, 78 % of BHS students take three years of science, and 46% take four years of science (and some of those have completed 5 or more science courses).

However, the science that students take is not NGSS aligned. Most BHS students take Biology in the 9th grade and Chemistry in the 10th grade. Afterwards, during their junior and senior years, students have access to a variety of science offerings. These are

heavily weighted toward the life sciences (AP Environmental Science, IB Environmental Science, Honors Anatomy, IB Biology, AP Biology, Biotechnology 1 and 2), but also include two physical science offerings (Physics and AP Physics). Students who need credit toward graduation (and who have failed earlier previous courses such as biology and/or chemistry) take Integrated science in their Junior or Senior years.

There are three problems with this current progression.

- 1) Currently, only about 20% of our students graduate having taken Physics at the AP or high school level.
- 2) Earth science (geology) and Space Science (Astronomy) are not studied at all.
- 3) With the exception of our Biotechnology program (which reaches only sixty juniors and seniors) and our physics program, we offer very little in terms of engineering.

Conclusion: If we want our students to experience a “state of the art,” NGSS aligned science education, then we need all students take **two** years of physical science and **one** year of life science, with earth science, space science, and engineering covered in a **three-year** progression.

Here’s our proposal for doing this.

2. 9th grade Physics, followed by 10th grade Chemistry and 11th grade Biology for all students

The following progression would enable all students to take coursework that aligns to NGSS content and skills.

GRADE 9 Course: Physics

This course would be different from the physics taught primarily to our juniors and seniors in that it would require less higher math. However, it would be highly mathematical, and explicitly seek to make connections with the math taught in our Math 1 program. In addition to covering topics traditionally associated with Physics, this course would also cover a variety of Space and Earth Science topics, allowing our students to learn about these mandated NGSS topics.

Physics First (9th Grade physics) is an approach that’s been promoted by Nobel Prize winner Leon Lederman, and is currently in use in programs schools such as the Head-Royce School (Oakland), Loyola High School (Los Angeles), Encinal High School (Alameda), and Capuchino High School (San Bruno).

GRADE 10 Course: Chemistry

This course would be different from the Chemistry currently taught to BHS 10th graders in that it would have to be realigned with NGSS chemistry standards. As with our 9th grade Physics course, this course would also include a variety of space and earth science topics.

GRADE 11 Course: Biology:

As with Physics and Chemistry, this course would have to be substantially different from the current Biology course taught to 9th graders at BHS. First, it would have to be aligned with NGSS life science standards. Second, as an 11th

grade course that would *follow* 9th grade Physics and 10th grade Chemistry, this course would have to be substantially redesigned to reflect the knowledge and skills with which our students will be entering this course. Third, along with physics and chemistry, Biology would have to include the Space and Earth science topics that would best fit within an life science class.

By teaching physics then chemistry then biology, we'll be not only be improving knowledge of physics at our school (which will happen because we'll increase the number of students taking physics from 25% to 100%), but we'll significantly improve chemistry and biology education, and hopefully increase the success rate of all students in these courses. Chemistry education will improve because we'll eliminate the "math shock" that many of our students experience as they transition from 9th grade biology, which has little math, to chemistry, which has mathematical reasoning as one of its core skills. In terms of biology, it should be noted that outside of reasons connected to the NGSS, the strongest argument for adopting a physics-chemistry-biology progression is that it reflects the reality of how *biology* has evolved as a discipline in the years since the "biology-first" progression became the standard in U.S. science education several generations ago. Unlike the biology that was taught 25 or 50 years ago, biology today is a science rooted in chemistry and physics. As DNA co-discoverer Francis Crick has said, "the ultimate aim of the modern movement in biology is in fact to explain *all* biology in terms of physics and chemistry."

3. Why other three year progressions *won't* work

As stated above, BUSD currently mandates two years of science. One of those years has to be a life science. The second has to be a physical science. We explained above why the current progression (Biology→ Chemistry→ anything goes) doesn't serve our need for NGSS alignment, because after passing Biology and Chemistry, students will have met their BHS graduation requirement, and will have no need to take physics. If we keep Biology in the 9th grade, and follow it with 10th grade Physics, then students have no reason to take Chemistry (having met their physical science requirement with their 10th grade physics class). The same is true if we start with Physics, and follow it with Biology.

4. What about BUSD mandating a three year science requirement?

If the BUSD Board of Directors were willing to mandate a three year science requirement for all BHS students, with courses in Physics, Chemistry, and Biology as part of that requirement that would help to ensure that all of our students take the science courses that they will need to have an NGSS-aligned science education. We advocate such a shift in requirements, and we would be happy to talk to the Board about the benefits adopting this requirement.

5. What about a two-year or three-year Integrated Science sequence?

Another way to organize science scope and sequence is through an integrated science approach. There are several reasons why we don't want to do this.

1. At the Alameda County NGSS rollout symposium in September, 2016, a two year integrated science approach was explicitly discouraged. It was, according to the

- conference organizers, insufficient to provide students with the breadth and depth of knowledge, as well as skillful mastery of science practices.
2. A three year integrated science approach could work...but only if the district mandated a three year science requirement (see above). Otherwise, many of our students would be exposed to only two thirds of the science they need. Also, based on current patterns of science course enrollment, we predict that many of the students who would stop taking science after two years would be ASI 3+ students, which, in BHS's racialized environment, largely maps to Black and Latino students. In other words, we'd be widening our achievement gap, and steering students who might benefit the most from a STEM education away from it.
 3. *Integrated science has a problematic reputation at BHS.* We currently offer a course called "Integrated Science" as a remedial class designed for seniors (and a small number of juniors) who are in danger of not meeting BHS graduation requirements. Integrated science can be taken for either Life Science or Physical Science credit. Consequently, based on this course's reputation, we could face significant resistance from families in the community to having their 9th graders enrolled in an Integrated Science course. While we realize that there is a possibility of rebranding the name "Integrated Science", we should start with a clear recognition of the challenge of selling this course to our community.
 4. *The integrated science approach is unpopular among BHS science teachers.* In the same way that French teachers *identify* as French teachers, there's a strong identification between science staff and their subject areas. The idea that a teacher would switch from his or her primary subject area and area of expertise (biology, chemistry, physics) and find themselves teaching Integrated science is unpalatable to many teachers. (Note: we recognize that this same factor presents difficulties in staffing 9th grade physics. We'll address this below.)

6. How will this change Impact Struggling Learners?

As mentioned above, our hope is that providing a 9th grade course that shows the connections between science and math will decrease the "math shock" that many of our students experience as they progress from 9th grade biology (which has typically not had a heavy emphasis on math) to Chemistry. Consequently, we're hoping that this change increases the success of all students in Chemistry, particularly the success rate of struggling learners. In addition, by emphasizing the use of math in science in our 9th grade course, we're hoping to increase success rates in both Math 1 and Math 2.

7. Physics First at BHS: Progress and Barriers

Progress: In a Science Department meeting in May of 2016, the BHS Science Department unanimously endorsed the idea of exploring the implementation of a 9th grade Physics course at BHS. This support has continued in subsequent meetings during the first semester of 2016-2017. During the summer of 2016, BHS physics teacher Stephen Salser was paid with BUSD NGSS curriculum development funds to spend two weeks sketching out a curriculum outline for a 9th grade physics course. He's agreed to train a cohort of teachers during the summer of 2017, and we're on track to

begin implementing the course with a up to 10 sections of 9th graders during the 2017-2018 school year.

Barriers: The main problem with implementing a 9th grade physics course is the number of BHS staff who are credentialed to teach Physics. Unlike, History, Math, or English, most science credentials are subject specific. In the same way that a Spanish teacher isn't qualified or credentialed to teach Mandarin, a Biology teacher isn't qualified or credentialed to teach Physics. Currently, we have 8 teachers on staff who are physics or physical science credentialed. If seven were teaching four sections of 9th grade physics, that would cover the need for the approximately 26 sections of freshman science that we teach each year. However, our two physics teachers are already teaching the five sections of AP and high school level Physics that our school currently offers (and we anticipate that seniors will continue to enroll in both classes). All of the other teachers are teaching Biology, chemistry, and/or integrated science. In short, we're going to need more physics teachers, which we'll have to address through teachers picking up supplementary authorizations, and new hires as we have our staff turn over from year to year.

CONCLUSION. A vision for science realignment at BHS

Imagine that it's 2020. BHS has moved to a three year science sequence that consists of Physics, then Chemistry, and then Biology. Success rates in Math 1 and math achievement overall has increased throughout BHS because of the math-infused science that students have experienced in their 9th grade Physics and 10th grade Chemistry courses. Failure rates in Chemistry have dropped because students have had the experience of using math in Physics for an entire year before being confronted with the mathematical challenges of Chemistry. Biology passing rates are significantly higher because all students are entering the course having taken Physics and Chemistry, enabling students to succeed in the increasingly molecularly-focused content that characterizes modern biological science. Students in all sciences have experienced the more student-centered and inquiry-focused methods that align with the NGSS science and engineering practices. More of our students are choosing science as a college major, and succeeding in college because of the rigor of their high school science experience.

8. How do we realize this vision? How do we realign to an NGSS aligned science curriculum that includes physics first, along with newly redesigned chemistry and biology courses?

1. *We need more teachers who are qualified and credentialed to teach Physics.*
The BHS science staff, as of fall of 2016, is a fairly stable crew. There are no retirements anticipated during the next five years, and the majority of our department is staffed by tenured teachers. To get more teachers who are qualified and credentialed to teach physics, we're going to have to retrain existing staff. We suggest that the district offer **recertification bonuses for teachers who pick up an additional authorization to teach Physics**. At the very least, BUSD should pick up the cost of the CSET test in physics.

In addition to taking the steps above, note that the BHS Redesign could also

offer us an opportunity to hire a few new teachers. In 9th and 10th grades, the redesign adds additional FTE to Science, which allows for opportunity to hire and additional Physics teachers onto our staff.

2. **We need to develop a new scope and sequence for all science courses at BHS.** As stated above, we need to figure out how to incorporate Earth science, Space science, and engineering into all science courses at BHS. This is work that needs to happen during the 2016-2017 school year, so that subsequent curriculum development can happen during the summer of 2017. We propose a six teacher Scope and Sequence Design team that will study the NGSS disciplinary core ideas and the new California science framework and develop a three year science scope and sequence for BHS science that maps to both. See attached spreadsheet for cost.
3. **We need to decisively resolve issues of certification for our 9th grade courses.** If it's required that anyone who teaches a course called "Physics" has a physics credential, fielding enough properly credentialed teachers to teach physics will be challenging. However, it's been argued that 9th grade science courses have different certification requirements than other science course. *We need clear answers about what credential is required to teach 9th grade Physics, and as soon as possible.*
4. **We need to allot a significant amount of time for development of a new 9th grade physics course.**

We suggest that this would happen in four main phases.

- a. Physics teacher Steven Salser gets paid for 100 additional hours of curriculum development time between now and the end of second semester, 2016. See attached spreadsheet for cost.
- b. Three physics teachers (Stephen Salser and 2 other teachers) get three weeks of paid curriculum development time this summer (summer of 2017) to prepare for teaching the first 8 sections of this course). Note that this will be much easier if the district determines the credentialing requirements for someone who teaches 9th grade physics. See attached spreadsheet for cost.
- c. Following the successful model that was used to get our Math department to align their courses with Common Core, we propose that these three teachers each get a full release period to continue to develop their courses, to observe one another, to develop common NGSS aligned formative and summative assessments, and to coordinate their curriculum with the Math 1 curriculum. See attached spreadsheet for cost.
- d. During the summer of 2018, three more teachers get trained for three weeks by one of the teachers who taught the course in 2017-18. This will allow us to expand to teaching all 9th graders physics for the 2018-2019

school year...just in time for the Berkeley High School Redesign. See attached spreadsheet for cost.

5. We need to redesign a new 10th grade chemistry course that's aligned to NGSS requirements and methods, and which incorporates appropriate Earth science, space science and engineering.

We believe that we can accomplish by doing the following.

- a. Three chemistry teachers meet for three weeks to adapt existing curricula to NGSS, and adopt new curricula as needed. Deliverables: a new scope and sequence for BHS chemistry, with shareable electronic lesson plans for the 1st semester of 2017-2018. See attached spreadsheet for cost.
- b. Note that if we were to follow the Math common core alignment model, each of these three teachers should be given 1 prep period during the 2017-2018 school year to continue to develop their courses, to observe one another, to develop common NGSS aligned formative and summative assessments, and to coordinate their curriculum with the Math 2 curriculum.

6. We need to redesign a new 11th grade biology course that's aligned to NGSS requirements and methods, and which incorporates appropriate Earth science, space science and engineering.

We believe that we can accomplish by doing the following.

- a. Three biology teachers meet for three weeks to adapt existing curricula to NGSS, and adopt new curricula as needed. Deliverables: a new scope and sequence for BHS biology, with shareable electronic lesson plans for the 1st semester of 2017-2018. See attached spreadsheet for cost.
- b. Note that if we were to follow the Math common core alignment model, each of these three teachers should be given 1 prep period during the 2017-2018 school year to continue to develop their courses, to observe one another, to develop common NGSS aligned formative and summative assessments, and to coordinate their curriculum with the Math 3 curriculum.

7. We need to jump start NGSS lesson planning with several rounds of teacher-led lesson study this year.

Lesson study involves two or more teachers collaboratively planning a lesson plan, delivering the lesson, then refining the lesson. This has been implemented at BHS several times over the last few years, with significant success. We can advance NGSS implementation for "early adopter teachers" by providing funds

for lesson study cycles by both life science and physical science teachers. Each cycle would involve three teachers meeting for two hours to plan a lesson, two hours to review video of the lesson as it's delivered in various classrooms, and two hours for refinement of the lesson. The deliverable for each cycle would be a field tested, NGSS lesson. See attached spreadsheet for cost of two cycles among life science teachers and two among chemistry teachers