Chapter 5A
Introduction to Grades Six Through Eight

The California Next General Science Standards (CA NGSS) defines two possible progressions for middle school: the preferred Integrated Model which interweaves science disciplines in a developmentally appropriate progression, and the Discipline Specific Model where each grade level focuses in depth on a different science discipline.

The two models differ only in the sequence; every student is expected to meet every middle school performance expectation by the end of 8th grade. “Sequence” here refers to which course (6th, 7th, or 8th grade) a particular Performance Expectation (PE) is mastered; this *Science Framework* makes no requirements about the order in which PEs are taught within a given year. (The example course sequences in this *Science Framework* describe possible storylines, but are not the only way).

Table 1 shows a comparison of which Disciplinary Core Ideas (DCIs) are emphasized in the PEs required at each grade level in the two models. For both models, all eight Science and Engineering Practices (SEPs) are developed and all seven Crosscutting Concepts (CCCs) are highlighted at some point during the course of every year (though each lesson may only focus on one or two and each year may have a slight emphasis on a subset).

As districts consider the progression that works best for their resources and local context, they should be aware of the historical context, rationale for each model, and potential limitations of each. This chapter outlines some of those issues.

Historical Background

The CA NGSS are aligned to the nationally developed NGSS. This nationwide effort specified specific PEs for grades K–5 but presented middle grade standards in a grade span of sixth through eighth grade. Because California is a kindergarten through eighth grade instructional materials adoption state, it requires that standards be placed at specific grade levels – sixth, seventh, and eighth. Therefore, the Superintendent of Public Instruction recommended that the State Board of Education adopt specific placement of the standards for middle grades at each grade level.

The Superintendent of Public Instruction convened the Science Expert Panel comprised of kindergarten through grade twelve teachers, scientists, educators, business, industry representatives and informal science educators. This panel evaluated a range of options for the appropriate organization and sequence of the PEs. The public provided feedback to the Science Expert Panel via three open forums and a webinar. The Science Expert Panel concluded that an integrated model for grades 6-8 would be the most effective model for optimizing student learning of NGSS; the panel subsequently reviewed the national model that had been developed by Achieve, and adapted it to better align with CA's needs and recommended only the Preferred Integrated Model to the State Board of Education. The full list of events that led to the adoption of the preferred integrated course model is described at the CDE Web site: http://www.cde.ca.gov/pd/ca/sc/ngssintrod.asp. On November 6, 2013, the State Board of Education unanimously passed the following motion: "To adopt the CDE staff recommendation that the SBE adopt the proposed integrated model as the preferred model for middle grades (6, 7, and 8) science instruction, and requested that the CDE reconvene the Science Expert Panel to develop as an alternative model a discipline specific model based upon the domain specific model outlined by Achieve in the NGSS Appendix K." In December 2014, the Science Expert Panel reconvened to develop a discipline specific model of the NGSS.

The Board's intent in their November action was for there to be one Integrated Model in California for grades 6–8 that was preferred by both the Superintendent of Public Instruction and the State Board of Education, and one Discipline Specific Model as an alternative.

Table 1. Comparison of When DCIs are Primarily Addressed in the Two Middle School Models

	Disciplinary Core Idea		Subtopic	Preferred Integrated			Discipline Specific		
				6	7	8	6	7	8
Earth & Space	**1**	**Earth's Place in the Universe**	Universe, Stars, Solar System			X	X		
			History of Planet Earth			X	X		
	2	**Earth's Systems**	Water Cycle, Weather, Climate	X			X		
			Rock cycle, Plate tectonics		X		X		
	3	**Earth and Human Activity**	Global climate change causes	X			X		
			Resources availability		X		X		
			Natural hazards		X		X		
			Resource consumption			X	X		
Life	**1**	**From Molecules to Organisms: Structures and Processes**	Cells & Body Systems	X				X	
			Photosynthesis & Respiration		X			X	
	2	**Ecosystems: Interactions, Energy, and Dynamics**			X			X	
	3	**Heredity: Inheritance and Variation of Traits**	Sexual v. Asexual reproduction	X				X	
			Mutations			X		X	
	4	**Biological Evolution: Unity and Diversity**				X		X	
Physical	**1**	**Matter and its Interactions**	Atoms, Molecules, States of Matter		X				X
			Chemical Reactions		X				X
	2	**Motion and Stability: Forces and Interactions**				X			X
	3	**Energy**	Kinetic Energy & Collisions	X		X			X
			Heat & Heat Flow	X					X
			Potential Energies & Gravity			X			X
	4	**Waves and Their Applications in Technologies for Information Transfer**				X			X
ETS	**Every course includes integrations with ETS**			X	X	X	X	X	X
SEP	**Every course utilizes all 8 SEPs**			X	X	X	X	X	X
CCC	**Every course highlights all 7 CCCs**			X	X	X	X	X	X

Learning from Other Successful Countries

The Science Expert Panel preferred the Integrated Model based in part on evidence of the performance of other countries and provinces. Analyzing the science standards of ten countries that produce significant scientific innovations and score highly on international benchmark tests, Achieve (2010) found that all ten of these countries use an integrated science model through middle school, and 7 of the 10 countries keep science integrated all the way through grade 10. Summarizing qualitative trends from their analysis, Achieve (2010) concluded that, "Standards based around 'unifying ideas' for Primary through Lower Secondary seem to confer more benefits than a discipline-based structure." This statement articulates part of the rationale behind the seven crosscutting concepts from CA NGSS that link together all disciplines of science and engineering. Given that these CCCs cannot be comprehended within a single context or even a single scientific discipline, the State Board adopted the Integrated model as the preferred model.

Matching University Training with Middle School Teaching

Many science teachers receive a university degree in a specific discipline of science within a specific university department (i.e., biology, chemistry, physics, geology), so they likely have stronger content knowledge in that field. Linda Darling-Hammond summarizes the research on the weak but measurable link between a teacher's subject matter knowledge and student achievement by saying that, "the findings are not as strong and consistent as one might suppose…. [perhaps] because subject matter knowledge is a positive influence up to some level of basic competence in the subject but is less important thereafter." (Darling-Hammond 2000) Teachers with a general science certification teaching middle school exceed that basic level of competence in all sciences and should be able to teach effectively in both models. Perhaps more important than university learning within a discipline is the pedagogical content knowledge learned from years of experience teaching a specific subject area. Some of this PCK (pedagogical content knowledge) is discipline specific (such as awareness of specific misconceptions within one's discipline) (Sadler et. al. 2013), but

much of it relates to SEPs and CCCs that span all disciplines of science and will transfer fluidly from one course model to the other. It was the judgment of the Science Expert Panel that teachers will remain highly qualified to teach in both the Preferred Integrated and Discipline Specific models.

Sequencing in a Developmentally-Based Learning Progression

CA NGSS is intentionally designed so that students slowly build up knowledge and skills in all three dimensions, addressing more sophisticated challenges or revisiting simple ones at a deeper level as they progress through the grades. Achieve also noted that even in exemplary standards, most countries paid insufficient attention to developmental learning progressions. They suggest, “developers of new standards will need to tease-out the prerequisite knowledge and skills, to provide a conceptual basis for understanding (Achieve 2010).” Appendix E of CA NGSS spells out the developmental progression of ideas within each discipline, but there is also prerequisite knowledge from one discipline that is applied in a separate discipline within CA NGSS, such as those illustrated in Table 2. The Preferred Integrated model was arranged with this sequencing in mind and the prerequisite knowledge is often placed within the same course so that it can be taught alongside the application. Successful implementation of the Discipline Specific model will require some remediation of the missing prerequisite knowledge, and the specific courses in this *Science Framework* identify when these situations occur in each course.

Table 2. Cross Disciplinary Learning Progressions

Prerequisite		Application	Grade level introduced (Prerequisite→Application)	
			Preferred Integrated	**Discipline Specific**
Gravity & Forces	→	Astronomy	8→8	8→6
Heat flow	→	Weather/Climate	6→6	8→6
Heat flow	→	Plate Tectonics	6→7	8→6
Chemical reactions	→	Photosynthesis	7→7	8→7
Chemical reactions	→	Energy from food	7→7	8→7
Chemical reactions	→	Carbon Cycle, Global Warming	7→7, 8	8→7, 6
Fossil Record	→	Geologic Time Scale	8→8	7→6
Scientific Notation	→	Scale in the Universe	8→8	8→6

The arrows represent a pathway from the prerequisite knowledge to an application of that knowledge. In the Discipline Specific Model, there are several topics where the application is introduced before the prerequisite knowledge.