Supplemental Material
CBE—Life Sciences Education
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Appendix

This supplement comprises the actual statements of the NRC K–8 life science content standards (NRC, 1996) and discussions of the strongest misconceptions linked to those standards that were identified during item field-testing. Assemblage of the relevant standards and misconceptions makes this document well suited to aiding precollege and in-service teachers in becoming aware of the prevalence and popularity of particular misconceptions among students.

It is important to note that students and teachers can share the most common misconceptions; such occurrences are marked in the tables with an asterisk. Many previous studies focused on particular misconceptions, such as identifying inanimate objects as "alive," or invoking Lamarckian agency in the passing on of traits. This study quantifies and orders popular misconceptions so that teachers can examine which misconceptions are the most common among students and consider their possible impact on learning. Certain misconceptions are discussed by standard in detail in the Commentary section for each standard, with references directing teachers to the relevant research papers. For each standard, a table is provided that lists the misconceptions identified in our field-testing; the proportion of all students at the relevant grade level who held these particular views (the misconceptions are listed from most to least popular based on our field-testing); and the misconception strength, i.e., the extent to which the students who were tested shared a particular misconception and calculated as the proportion of all students who selected the same misconception from among all students who chose any incorrect answer. One should note that we define a strong misconception as those inaccurate ideas that were chosen at a level of ≥0.50 by all students who selected an incorrect answer on our field tests.

Although this supplement does contain some explanations as to how some misconceptions may arise, as found in the published research literature, this information is provided only as examples of how student thinking may be influenced. This study did not attempt to determine the origin of misconceptions, but only to identify misconceptions present among K-8 students and teachers for use as probes for the presence or absence of scientifically accurate concepts. For more information on the general origins of students' scientific misconceptions, the reader should consult: Cho, Kahle and Nordland (1985) for a discussion of textbook errors; Yip (1998) for the role of teachers' misconceptions; McCloskey (1983) for the issue of misperception of the world; Strike and Posner (1992) for an account of misleading metaphors; Thijs and Berg (1995) for the role of cultural factors; Wandersee (1986) for historical recapitulation; and diSessa (1993) for the application of phenomenological primitives (p-prims). For a discussion of the origin of a particular misconception, the references within each commentary section should be helpful. Furthermore, while the identified misconceptions are listed from most to least common as found in our study, this

ordering is not intended to imply the degree of impact on learning of a misconception, or how or whether to address any misconception, issues not addressed by our study.

A. K-4 Standards and Misconceptions.

I. NRC Standard, The Characteristics of Organisms

Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light. Organisms can survive only in environments in which their needs can be met. The world has many different environments, and distinct environments support the life of different types of organisms.

Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking.

The behavior of individual organisms is influenced by internal cues (such as hunger) and by external cues (such as a change in the environment). Humans and other organisms have senses that help them detect internal and external cues.

a) Relevant Misconceptions

Table A1. Misconceptions Identified in the K-4 Grade Band Related to Standard I. The list is of items that identified strong misconceptions (Misconception Strength $\geq$ 0.50.) in the K-4 item inventory related to Standard I. The "Proportion of all students" column states the proportion of students who chose that answer. "Misconception Strength" shows the proportion of students who chose the misconception out of all of those students who chose any incorrect response. Starred misconceptions are those shared by some teachers.

Misconception	Proportion of all students	Misconception Strength (popularity among those with wrong answer)
Plants breathe through their roots	0.42	0.58
Plants use their leaves for water collection	0.39	0.68
Plants do not reproduce sexually	0.33	0.51
The brain is not involved with sensory perception; only the organ directly associated with the sense is involved	0.31	0.74
Lions and tigers both live in the savannah*	0.30	0.78
Seeds and eggs are not alive until humans intervene (e.g., water the seed); plants create seeds so that animals can eat those seeds (i.e., not for their own reproduction)	0.24	0.56

Plants are not alive	0.20	0.57
The sun is alive; water is alive	0.17	0.66

b) Commentary

The concept of "alive" can be complicated for young students. Some young students believe that anything exhibiting motion is alive, so fire and clouds may be classified as alive, while seeds, eggs and trees may not (Driver *et al.*, 1994; Brumby, 1982; Stavy & Wax, 1989; Tamir *et al.*, 1981; Carey, 1985; Inagaki, 1989; Ochiai, 1989; Mintzes & Arnaudin, 1984; Wandersee *et al.*, 1994). Other qualifications for being alive may include easily observable characteristics (e.g., breathing) or a potential (e.g., reproduction). Children may anthropomorphize objects (e.g., teddy bears or cars) and then consider them to have feelings and thoughts (Driver *et al.*, 1994; Bell & Freyberg, 1985; Piaget, 1972; Vygotsky, 1986). Visual associations between plant parts and common human-made devices may perpetuate stereotypes, such as the similarity between a tube and a stem leading to the misconception that a plant stem sucks air out of the ground; or that between a bowl and a leaf leading to the misconception that plants obtain water through their leaves. An anthropomorphic viewpoint also lends support to the development of the misconception that animals and plants exist solely to feed humans (Driver *et al.*, 1994).

II. NRC Standard, Life Cycles of Organisms

Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms.

Plants and animals closely resemble their parents.

Many characteristics of an organism are inherited from the parents of the organism, but other characteristics result from an individual's interactions with the environment. Inherited characteristics include the color of flowers and the number of limbs of an animal. Other features, such as the ability to ride a bicycle, are learned through interactions with the environment and cannot be passed on to the next generation.

a) Relevant Misconceptions

Table A2. Misconceptions Identified in the K-4 Grade Band Related to Standard II. The list is of items that identified strong misconceptions (Misconception Strength $\geq$ 0.50.) in the K-4 item inventory related to Standard II. The "Proportion of all students" column states the proportion of students who chose that answer. "Misconception Strength" shows the proportion of students who chose the misconception out of all of those students who chose any incorrect response. Starred misconceptions are those shared by some teachers.

Misconception	Proportion of all students	Misconception Strength (popularity among those with wrong answer)
Any two animals can mate and produce offspring as long as the two animals are male and female*	0.56	0.89
Traits are developed because of need, want or desire (agency)*	0.53	0.79
Seedlings do not resemble parent plants	0.51	0.70
DNA can change completely based on environment; i.e., a poodle raised among beagles will grow up to be a beagle	0.45	0.62
All taller and darker living things are older than shorter and lighter living things	0.41	0.67
All kinds of flora exist only to feed fauna	0.40	0.54
Habits and behaviors often taught to particular animals are inherited, e.g., dogs returning a ball, parrots talking	0.40	0.54
Seeds develop from roots, not flowers	0.37	0.57
All eggs are fertilized before they are laid	0.35	0.58
Traits developed over a lifetime can be passed onto offspring (Lamarckian viewpoint)	0.34	0.58
Trees always grow straight and tall*	0.34	0.58
Without human intervention, trees live forever	0.28	0.61
The phenotype(s) of the mother determines the phenotype(s) of the offspring	0.28	0.76
Traits not used within a lifetime are lost within that lifetime	0.25	0.55
Similar phenotypic anatomy means similar origin, function and development, e.g., birds and butterflies both go through metamorphosis based on presence of wings	0.12	0.58
Male children resemble their father; female children resemble their mother	0.12	0.64

b) Commentary

Many of the misconceptions in this standard can be attributed to observation and simplification, the first of which is a basic tenet of K–4 science education according to the NRC Standards (NRC, 1996). Reproduction appears to be taught in U.S. public

schools at this grade level in an oversimplified form, an approach attributable to both a need for a particular moral educational environment, as well as the maintenance of the "innocence of childhood" in response to the oversexualization of youth in society (Moore, 1993). In addition, parents maintain their right to educate their own children about sex and reproduction, and have launched several lawsuits in an attempt to ban sex education from schools (Brown, 2009). This oversimplification (and perhaps observation, depending on where a student lives and to what she has been exposed) may be the basis for many misconceptions, including that procreation is possible between any male animal and female animal (Berthelsen, 1999). Similarly, everyday observational associations may lead to other misconceptions, e.g., a tree grows straight and tall (as a child might draw a stereotypical tree); children most resemble, and therefore inherit their physical traits from, the parent with whom they have gender in common (Deadman & Kelly, 1978; Clough & Wood-Robinson, 1985; Kargbo *et al.*, 1980). A Lamarckian understanding of inheritance (Berthelsen, 1999; D'Avanzo, 2008; Wilson *et al.*, 2006; Bardapurkar, 2008; Bishop & Anderson, 1990; Stern & Ben-Akiva, 2007; Tamir & Ben Peretz, 1988) can be partially attributed to anthropomorphism, and to adages and maxims ("If you strive hard enough, you can have anything you want").

III. NRC Standard, Organisms and Their Environments

All animals depend on plants. Some animals eat plants for food. Other animals eat animals that eat the plants.

An organism's patterns of behavior are related to the nature of that organism's environment, including the kinds and numbers of other organisms present, the availability of food and resources, and the physical characteristics of the environment. When the environment changes, some plants and animals survive and reproduce, and others die or move to new locations.

All organisms cause changes in the environment where they live. Some of these changes are detrimental to the organism or other organisms, whereas others are beneficial.

Humans depend on their natural and constructed environments. Humans change environments in ways that can be either beneficial or detrimental for themselves and other organisms.

a) Relevant Misconceptions

Table A3. Misconceptions Identified in the K-4 Grade Band Related to Standard III. The list is of items that identified strong misconceptions (Misconception Strength $\geq$ 0.50.) in the K-4 item inventory related to Standard III. The "Proportion of all students" column states the proportion of students who chose that answer. "Misconception Strength" shows the proportion of students who chose the misconception out of all of those students who chose any incorrect response. Starred misconceptions are those shared by some teachers.

Misconception	Proportion of all students	Misconception Strength (popularity among those with wrong answer)
Helping the environment is only a benefit to humans; humans can best help the environment by making slight alterations to what they already do	0.49	0.69
Animals die if humans don't feed them; they will not adapt to eat what's available	0.41	0.61
Within a food web, only those organisms directly connected to an affected organism will also be affected (there is only first order association)	0.35	0.59
Things that die disappear	0.30	0.52
Trees provide only hiding places and food for animals	0.25	0.85
Camouflage (fur) is for warmth; green camouflage allows an organism to perform photosynthesis	0.25	0.77
Lamarckian agency in trait development over a season or lifetime, e.g., bears decide to make their fur thicker in winter	0.13	0.63
Animals all eat animals smaller than themselves	0.10	0.50
All birds are herbivores; bugs, insects, snails do not eat*	0.05	0.51

b) Commentary

Again, the majority of misconceptions in this standard are based on observation, anthropomorphism and stereotypical images presented to children in textbooks and popular culture. For children in this grade band, the food web seems to work in a one-dimensional, linear fashion. Small animals do not hunt and therefore must be herbivores (or do not eat at all), while larger animals are carnivores that eat animals smaller than themselves (Strommen, 1995; Driver *et al*., 1994). Students also believe that adaptation arises from an acute desire or need, which is both Lamarckian (see citations above) and a result of the language used by teachers and textbooks, which confuses

biological with common use definitions of adaptation (Jungwirth, 1975; Clough & Wood-Robinson, 1985).

B. 5–8 Standards and Misconceptions

I. NRC Standard, Structure and Function in Living Systems

Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems.

All organisms are composed of cells – the fundamental unit of life. Most organisms are single cells; other organisms, including humans, are multicellular.

Cells carry on the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires that they take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or an organism needs.

Specialized cells perform specialized functions in multicellular organisms. Groups of specialized cells cooperate to form a tissue, such as a muscle. Different tissues are in turn grouped together to form larger functional units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.

The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination, and for protection from disease. These systems interact with one another.

Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.

c) Relevant Misconceptions

Table A4. Misconceptions Identified in the 5-8 Grade Band Related to Standard I. The list is of items that identified strong misconceptions (Misconception Strength ≥ 0.50.) in the 5-8 item inventory related to Standard I. The "Proportion of all students" column states the proportion of students who chose that answer. "Misconception Strength" shows the proportion of students who chose the misconception out of all of those students who chose any incorrect response. Starred misconceptions are those shared by some teachers.

Misconception	Proportion of all students	Misconception Strength (popularity among those with wrong

		answer)
Most organisms on earth are multi-cellular*	0.66	0.83
Every cell is a tiny organism	0.46	0.55
Energy comes from protein, not carbohydrate	0.43	0.56
Diseases are caused by "germs" and cold weather	0.38	0.55
Unless directly stimulated, the nervous system is not involved in human body functions	0.36	0.69
Viruses and bacteria are cellular	0.30	0.54

d) Commentary

Because the summation of current cell theory as stated in middle school life science textbooks is that the cell is the basic unit of structure and function of all living things, it was not surprising that our field-testing confirmed that students at this age assume that all organisms are multi-cellular. The typical experiment appropriate to this age group involves the observation of pond water; students tend to understand the variety of unicellular organisms in pond water, for example, as typical of all cells (e.g., all organisms are made up of millions of hydra or amoeba), thus reinforcing the misconception that all cells are tiny organisms (but not independently viable organisms). Students tend to take an anthropomorphic view of the world as a whole and assume that humans, as a dominant life form, are more numerous than most other species, and therefore most organisms are multi-cellular.

Students generally misunderstand the interconnectedness of the various human body systems at this age (Carey, 1985; Driver *et al*., 1994; Kwen, 2005). Students learn about each system separately and thus tend to believe that the systems work in isolation from each other (Sweetland, 2011). Any concept that the functioning of systems involves complex interactions among the systems, and that system functions are activated by feedback and stimulation, is typically presented in later education.

II. NRC Standard, Reproduction and Heredity

Reproduction is a characteristic of all living systems; because no individual organism lives forever, reproduction is essential to the continuation of every species. Some organisms reproduce asexually. Other organisms reproduce sexually.

In many species, including humans, females produce eggs and males produce sperm. Plants also reproduce sexually – the egg and sperm are produced in the flowers of flowering plants. An egg and sperm unite to begin development of a new individual. That new individual receives genetic

information from its mother (via the egg) and its father (via the sperm). Sexually produced offspring never are identical to either of their parents.

Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.

Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.

The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited and others result from interactions with the environment.

a) Relevant Misconceptions

Table A5. Misconceptions Identified in the 5-8 Grade Band Related to Standard II. The list is of items that identified strong misconceptions (Misconception Strength $\geq$ 0.50.) in the 5-8 item inventory related to Standard II. The "Proportion of all students" column states the proportion of students who chose that answer. "Misconception Strength" shows the proportion of students who chose the misconception out of all of those students who chose any incorrect response. Starred misconceptions are those shared by some teachers.

Misconception	Proportion of all students	Misconception Strength (popularity among those with wrong answer)
Plants only reproduce asexually*	0.69	0.87
Phenotypic traits not involved with the individual's desire for change are only determined by the genes inherited from the parents (e.g., height, hair color)*	0.63	0.89
The genetic coding for a particular organ is only found in the cells of that organ (e.g., eye color is determined only by the DNA in eye cells)	0.39	0.57
Specialization is really mutation*	0.35	0.51
Water does not aid in pollination*	0.33	0.54
The genetic changes due to need, desire and environment can be passed down to the organism's progeny	0.23	0.59

Reproduction and copulation are equivalent; both are performed for pleasure.	0.22	0.60

b) Commentary

The concept that sexual reproduction occurs in animals, but not in plants is well established in the literature (Driver *et al*., 1994; Berthelsen, 1999; Gott *et al*., 1985), as is the Lamarckian understanding of inheritance (Berthelsen, 1999; D'Avanzo, 2008; Wilson *et al*., 2006; Bardapurkar, 2008; Bishop & Anderson, 1990; Stern & Ben-Akiva, 2007; Tamir & Ben Peretz, 1988). Again, these concepts may be related to an anthropomorphic viewpoint common in the psychological development of children in this age band. Sexual reproduction is associated with human copulation or the act of mating as observed in other relatively large mammals, such as dogs or cats. An organism's "desire" for a different trait or body part in order to accomplish a task (such as a giraffe being able to eat the topmost leaves on a tall tree) can transform an organism's genetic material within its lifetime and enable the organism to pass the desired trait to its offspring. Popular culture, common phraseology and frequently used maxims may reinforce these notions as well.

III. NRC Standard, Regulation and Behavior

All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.

Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive.

Behavior is one kind of response an organism can make to an internal or environmental stimulus. A behavioral response requires coordination and communication at many levels, including cells, organ systems, and whole organisms. Behavioral response is a set of actions determined in part by heredity and in part from experience.

An organism's behavior evolves through adaptation to its environment. How a species moves, obtains food, reproduces, and responds to danger are based in the species' evolutionary history.

a) Relevant Misconceptions

Table A6. Misconceptions Identified in the 5-8 Grade Band Related to Standard III. The list is of items that identified strong misconceptions (Misconception Strength $\geq$ 0.50.) in the 5-8 item inventory related to Standard III. The Proportion of all students column gives the proportion of students who chose that answer. Misconception Strength shows the proportion of students who chose the misconception out of all of those who chose any incorrect response. Starred misconceptions are those shared by some teachers.

Misconception	Proportion of all students	Misconception Strength (popularity among those with wrong answer)
Habits and behaviors are based on need and desire rather than evolutionary advantage	0.44	0.65
A virus survives because humans host it, not because it adapts	0.44	0.67
The act of reproducing helps to maintain homeostasis	0.42	0.57
An organism's genetic code can change during their lifetime, according to their needs, desires and environment (e.g., a blond baby born to brunette parents must live in Scandinavia)	0.33	0.60
Automatic responses require no thinking and yet only involve the nervous system*	0.32	0.78

b) Commentary

Evolutionarily advantageous behaviors developing as a matter of conscious need, rather than as an effect of organisms behaving so as to reproduce, is another concept well documented in the research literature (University of California/Berkeley, 2010; Driver *et al*., 1994; Munson, 1994; Anderson *et al.*, 2002; Klymkowsky *et al.*, 2003; Williams *et al.*, 2008; also see Lamarckian understanding citations above).

IV. NRC Standard, Populations and Ecosystems

A population consists of all individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem.

Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some micro-organisms are producers – they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem.

For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.

The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem.

a) Relevant Misconceptions

Table A7. Misconceptions Identified in the 5-8 Grade Band Related to Standard IV. The list is of items that identified strong misconceptions (Misconception Strength $\geq$ 0.50.) in the 5-8 item inventory related to Standard IV. The "Proportion of all students" column states the proportion of students who chose that answer. "Misconception Strength" shows the proportion of students who chose the misconception out of all of those students who chose any incorrect response. Starred misconceptions are those shared by some teachers.

Misconception	Proportion of all students	Misconception Strength (popularity among those with wrong answer)
A population is all of the organisms living in one place at one time	0.58	0.81
Ecosystems only include biotic components; abiotic factors are not part of the ecosystem	0.49	0.64
Extinction is mostly due to human intervention	0.38	0.61
Humans are not members of ecosystems*	0.37	0.53
Organisms eat in order to get energy only (not both energy and matter)*	0.34	0.69
The original source of energy for an ecosystem is the primary producer, rather than the sun	0.33	0.59
Organisms share niches without competing because they get along well with each other	0.27	0.56

b) Commentary

The common student dismissal of humans as animals or as members of an ecosystem may be related to students' anthropomorphic viewpoint (Sweetland, 2011; University of California/Berkeley, 2010; Inagaki & Hatano, 1987), as well as the notion held by some teachers that if children were taught that they are animals, they would behave like animals (Ruse & Travis, 2009). Various opponents to the theory of evolution have published other comments and explanations concerning why young students should not be taught that humans are animals, or even exposed to the concept evolution at all (Miller *et al.*, 2006; Bhattacharjee, 2009).

Misconceptions about food webs may be due, in part, to the textbook diagrams that students study, as well as a mistaken understanding of the food chain (Brumby, 1982; Griffiths & Grant, 1985; Munson, 1991; Lennon & DeBoer, 2008; Barman & Mayer, 1994; Fries-Gaither, 2009; Hogan, 2000). Also, because matter is rarely discussed in conjunction with the food web, while energy is emphasized, the misconception that eating provides an organism with energy (but not matter) seems relatively reasonable. Diagrams of food webs in textbooks tend to show only the biotic factors in ecosystems, so the abiotic factors (such as the energy from the sun) are generally not discussed.

V. NRC Standard, Diversity and Adaptations of Organisms

Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry.

Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.

Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on the earth no longer exist.

a) Relevant Misconceptions

Table A8. Misconceptions Identified in the 5-8 Grade Band Related to Standard V. The list is of items that identified strong misconceptions (Misconception Strength $\geq$ 0.50.) in the 5-8 item inventory related to Standard V. The "Proportion of all students" column states the proportion of students who chose that answer. "Misconception Strength" shows the proportion of students who chose the misconception out of all of

those students who chose any incorrect response. Starred misconceptions are those shared by some teachers.

Misconception	Proportion of all students	Misconception Strength (popularity among those with wrong answer)
Lamarckian agency in trait development over a season or lifetime, e.g., bears decide to make their fur thicker in winter	0.55	0.81
Very few species have gone extinct; those that have are dinosaurs, insects and some other animals (dodos, for example)*	0.46	0.65
A high percentage of DNA codes for phenotype, e.g., having 98% of human genes in common with chimpanzees makes humans and chimpanzees the same species.	0.13	0.52

b) Commentary

An anthropomorphic perspective and the impact of popular culture (particularly in movies) likely underlie development of the misconception that extinction is mostly due to human intervention. For example, it is the rare life science classroom in which human decimation of the rainforest is not discussed. Popular media and common lessons have also reinforced the notion that very few species have gone extinct, since only a few specific cases, such as dinosaurs, are widely discussed, while the overarching history of our planet and extinction is simplified (Berthelsen, 1999; Wilson *et al.*, 2006; Mayr, 1982; Clough & Driver, 1986; University of California/Berkeley, 2010).

A more complex issue is accurately conveying the concept of having some DNA in common with other organisms and what that might mean about the evolutionary history of a species. Evolutionary trees––although not specified in the NRC 5–8 life science standards, but presented in many middle school life science textbooks––can be very confusing and may generate their own misconceptions (Berthelsen, 1999; Wilson *et al.*, 2006; University of California/Berkeley, 2010). In addition, there are competing theories about the evolution of humans––scientific and religious—and therefore not all children are learning to the same depth about the similarity of DNA among species (Miller *et al.*, 2006). It should also be noted that the concept of genetic coding is a relatively recent addition to grades 5–8 life science courses and thus little research literature currently exists on this topic.