A3 Unity and diversity

Lesson 1

Topic	**A3.1 Diversity of organisms**
Lesson	**Classifying organisms and the definition of ‘species’.**
Level	SL and HL
Duration	1.5 hours
Lesson context	This lesson introduces the formal definitions of ‘species’ and the concept of how new species can be generated. Speciation splits are discussed in much more detail in A4.1 so there is no need to go into detail about different types of barriers.
Students should understand	**A3.1.1–A3.1.5:** • how to define and name each species • how to decide that a species split has happened, when a population is separated in two and does not breed together anymore.
Potential misconceptions	• There is a single way to classify life on Earth and that all experts follow it. • Scientific names should be written with either both names in lower case or both capitalized. • Speciation is a rapid and unambiguous process.
Plan for how students will acquire knowledge, understanding and skills	• Read sections A3.1.1–A3.1.5. • Attempt Exercise questions 1–4 on page 121.

Possible Activities	Students complete the Challenge yourself activity, on page 98, to find scientific names for species they encounter in their daily lives. For example, if they look up tomato and potato, they might be surprised to see they come from the same genus, *Solanum*, as do eggplants. Organize students into groups and provide images of organisms of the same species, asking them to list similarities and differences. Then provide images of a variety of species to classify. *How many ways can they come up with to put the organisms in groups? Are some ways more useful than others?* Pick one example of a species and apply the two definitions of 'species' given in the chapter. Students work in groups to examine a case study of a speciation such as Galapagos finches, squirrel species on the north and south rims of the Grand Canyon, *Anolis* lizards in the Caribbean or *Drosophila* lab experiments feeding one half of the population starch and the other maltose.
Links to IB concepts (e.g. NOS, TOK)	Do the categories we use truly exist in nature, or just in our minds? How does the current system used to classify species show international mindedness? What should be appreciated more: our similarities or our differences?
Key questions to check for understanding	Guiding Question: What is a species? Linking Question: How do species exemplify both continuous and discontinuous patterns of variation? Linking Question: What might cause a species to persist or go extinct?
Additional resources for support/extension	The Tree of Life project (tolweb.org) has photos of very diverse species and shows how closely they are (or are not) related. An online image search could be used to see variation within a species such as *Heliconius charithonia*, the zebra longwing butterfly.

Lesson 2

Topic	**A3.1 Diversity of organisms**
Lesson	**An organism's chromosomes and DNA sequences can help us learn about their similarities and differences.**
Level	SL and HL
Duration	1.5 hours
Lesson context	From their studies of A1.2, students should be familiar with the concept of DNA and how its universal code shows common ancestry, but they might not yet have covered mutations (in D1.2 and D1.3) or evolution (A4.1). From their studies of A2.2, students should know what chromosomes are, but this is the first time they will focus on the number of chromosomes different species possess. Tool 1 – experimental techniques: karyotyping is introduced in this lesson.
Students should understand	**A3.1.6–A3.1.10:** • that the number of chromosomes a species has is characteristic of that species • how karyotyping techniques allow us to map the chromosomes according to size, shape and banding patterns • how to examine the evidence for the origin of human chromosome 2.
Potential misconceptions	• It is always true that the more chromosomes a species has, the more complex it is. • Chromosomal anomalies are synonymous with genetic diseases.
Plan for how students will acquire knowledge, understanding and skills	• Read sections A3.1.6–A3.1.10. • Attempt Exercise questions 5–7 on page 121.

Activities	Students research chromosome numbers of their favorite plants and animals, such as their pets or the kinds of fruit they like to eat. Students working individually can build a karyogram from a printout or using an online simulation. Using examples of other karyograms, they can answer questions about the defining number of chromosomes. Students working in groups can compare genome sizes of various species. They can debate whether or not more genetic material means a more complex organism. Students can quiz each other on the evidence for the origin of human chromosome 2. Groups can be assigned a specific current or future use of genome sequencing to research and present to the class.
Links to IB concepts (e.g. NOS, TOK)	NOS box on page 106: Some claims are testable and others are not. TOK box on page 108: Ethical questions raised about home DNA testing kits.
Key questions to check for understanding	Guiding question: What patterns are seen in the diversity of genomes within and between species?
Additional resources for support/extension	The Learn Genetics website from the University of Utah has a page called “make a karyotype” allowing students to match up chromosomes on the screen based on size and banding patterns. The CyDAS.org web site has a “drawing a karyogram online” page.

Lesson 3

Topic	**A3.1 Diversity of organisms**
Lesson	**Challenges to the biological species concept, cross breeding, making a dichotomous key, DNA barcoding**
Level	HL
Duration	2 hours
Lesson context	Students are already familiar with the biological species concept but here they see the concept of a hybrid for the first time. More on interspecific hybrids in A4.1. The concept of biodiversity is introduced here but will be dealt with in more depth in A4.2.
Students should understand	**A3.1.12–A3.1.15:** • how we apply the biological species concept to organisms that do not breed sexually • what happens when we cross-breed species with similar but nonidentical chromosome numbers • how we can build our own dichotomous key to identify a local plant or organism • some applications for the DNA barcoding of environmental DNA.
Potential misconceptions	That both definitions for the term 'species' can work for sexually and asexually reproducing organisms.
Plan for how students will acquire knowledge, understanding and skills	• Read sections A3.1.12–A3.1.15. • Attempt Exercise question 7 on page 121. • Skill activity link on page 117: **Develop your own dichotomous key** for local plant or animal species. Students should make one as homework and bring it in to class for classmates to test.

Activities	Try the biological species concept definition on a variety of organisms, some of which are bacteria, some extinct such as the wooly mammoth. Use the diagram on page 115 to explain why horizontal gene transfer poses a problem for the biological species concept. Test classmates' dichotomous keys (skill activity link on page 118). Examine a case study of eDNA. Use an online database such as the Barcode of Life data project.
Links to IB concepts (e.g. NOS, TOK)	The branchings from common ancestors make up the model of the 'tree of life' which has evolved from earlier models such as ladders. What are the strengths and limitations of this model? Since we do not have baseline numbers for biodiversity in most of the world's ecosystems, we cannot know if current eDNA studies show an increase or decrease in biodiversity. Collecting aquatic eDNA samples has fewer logistical difficulties than collecting terrestrial samples. How could this generate a sampling error or bias?
Key questions to check for understanding	Guiding question: What is a species?
Additional resources for support/extension	A short online video called 'BIOSCAN: tracking biodiversity on Earth' shows how DNA analysis is being used to measure biodiversity. A slightly longer video can be found by searching for 'NOAA ocean explorer environmental DNA'. The Wiley online library has scientific articles on the subject, notably 'Terrestrial mammal surveillance using hybridization capture of environmental DNA from African waterholes'. DNAbarcoding101.org has examples of high school student projects that used DNA barcoding to discover new species near their schools.

