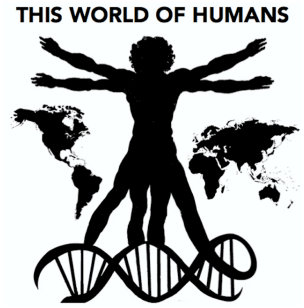

Visionlearning®
your insight into science

This World of Humans: Episode #6
Guide for Educators

Detection of Natural Selection in our Genes

These activities address NGSS LS3.A, LS4.A, and LS4.B, as well as specific Cross-Cutting Concepts and Science and Engineering Practices (see page 5). Many are also suitable for courses designated as "Writing-Intensive."

About the Article

This article presents a new model (MASS-PRF) for quantifying the variability of selection that occurs in specific regions on a genome. Through this approach, the researchers were able to compare the genome of humans to that of chimpanzees, ultimately identifying regions where selection has altered gene sequences and led to the species divergence.

About the interview

In this interview, Dr. Campbell explains the methodology behind the MASS-PRF model and how the team discovered that selection at particular regions on the human genome may be responsible for the ancestral genetic divergence that led to chimpanzees and human beings.

Both the article and the interview can be found here: https://www.visionlearning.com/en/twoh/#ep6

Recommended: pair these materials with the following Visionlearning modules: *Population Genetics*, *Gene Expression*, *DNA I*, *DNA II*, *and DNA III* (https://www.visionlearning.com)

Use in the Classroom

These materials are useful for exploring ways in which scientists use technological advances to develop new methodologies. They also assist in building understanding of the different ways in which scientific information can be conveyed. Students may benefit from listening to the interview before reading the article.

1. **Pre-reading and pre-listening activities** are provided to prompt prior knowledge and help students make connections between their own lives and the research they are learning about. Materials may be used in the classroom to generate discussion, or as homework if the article or interview will be read/listened to in-class. Having students write before speaking helps focus discussions and reading.
2. The **worksheets** are explicitly designed to walk students through the process of reading a scientific paper, as well as building disciplinary vocabulary. They serve as excellent homework assignments (if the article is read outside of class) and will direct students toward identifying important information about the research. While the answers provided can be used to check student reading, it is really an opportunity to assist students in how to read scientific material. Completed worksheets are excellent for small group discussions, allowing students to solve any discrepancies themselves, or as a debrief with the entire class.
3. **Post-reading and -listening activities** are designed to extend student thinking and engage them more deeply with the text and interview. These questions are great for small groups, for large class discussions, or for short-answer writing assignments.

Guide for Educators

Pre-reading and –listening activities

1. **Vocabulary preparation:** Provide students with the Vocabulary Worksheet and ask them to offer definitions. Clarifying terminology as a class is recommended. This worksheet is suitable for a 20-minute in-class activity if students have access to dictionaries or the internet. Many of the terms are specific to primatology, thus *context* is critical to reinforce when assigning this activity.

2. **Free-writes**: Freewriting is a practice where an individual writes continuously what comes to their mind (by hand or typing) for a specified period of time. The point of the exercise is to generate thoughts, not quality prose. Periods of 5 minutes (timed) are best for the questions posed below. It also helps to write the question on the board, or print it on a handout, so that students can refer back when necessary. *Do not collect these* – it should be a low-stakes writing task. However, you can ask for students to volunteer what came to mind and use these thoughts to generate discussion about the article they will be reading. ***Instructions to students:***

   We are going to do an exercise called a 'freewrite'. Please take out a notebook or blank sheet of paper, and something to write with. If you're using a computer – open a new file in your word processor. In a moment, I will give you a question to think about, then I'll set a timer for 5 minutes. During this time, I do not want you to stop writing. That means your pen or pencil should keep touching the paper, or your fingers pressing the keys. The point, here, is to write whatever comes to mind without any censoring or editing. Just your thoughts. If you can't think of anything, write "I can't think of anything." You do not have to share your thoughts unless you want to – I will not collect these. Here is the question I want you think write about: [instructor: pick one]

   1. *Humans and chimpanzees share a significant portion of their genome – only ~1.5% of the genome differs between the two organisms. What, do you think, can explain why chimps and humans look and behave so differently?*
   2. *What are the benefits to society of researching the ways in which natural selection works on a genetic level?*
   3. *Describe natural selection and how it works on genes.*
   4. ***(Advanced)** What is the difference between coding and non-coding DNA?*

Post-reading and –listening activities

1. **Revisiting vocabulary:** Using the vocabulary sheet students completed at the start, clarify as a group/class how the authors used the terms. Were they used the same? Differently? Explain.

2. **Sketch a genome:** During the interview, Dr. Campbell discusses how the selection that has taken place at "hot spots" on the human genome seems to have provided selective advantage to humans. Pretend you are explaining to a layperson how humans and chimpanzees differ genetically. Create an illustration of what this looks like. Draw on the explanations provided in both the article and interview to simplify the process so that a layperson can visualize what changes may have occurred over time to create such different, yet similar, organisms.

3. **Discussion/Writing questions:** Use the following list of questions to engage students in thinking more critically about the research and interview. These questions can be assigned as short-essay prompts, used

for small-group discussion, or used to prompt whole-class discussion. Ask students to refer directly to the paper or interview to support their answers. Some questions (denoted **VL**) are appropriate for use with the learning module *Population Genetics* (https://www.visionlearning.com/en/library/Biology/2/Population-Genetics/249)

- **(VL)** *In the learning module* Population Genetics, *Warmflash and Lents explain two different types of genetic drift. Drawing on each of the descriptions, explain how these might influence "hot spots" on a genome. How might Zhao et al.'s work extend this process?*
- *In the interview, Campbell explains how they used the MASS-PRF in a variety of ways. What did the different applications help the team learn about genomes and selection?*
- *In the interview, Campbell talks about drawing on the field's previous research to design the MASS-PRF project. What are the implications for the research this team conducted, and how might it be extended by other researchers?*
- *Campbell's research team has helped expand our knowledge of the ways in which genetic adaptation and mutation influence how genes function and present advantages. What ethical concerns arise from our ability to more comprehensively understand the ways in which selective advantage works?*
- *Using common, everyday language, explain Zhao et al.'s research and findings.*

4. **Write a "microtheme":** A "microtheme" is an essay so short that it can be typed on a single five-by-eight inch notecard (about 150 words). It is a type of assignment where a small bit of writing is preceded by a great deal of thinking.[1] Microthemes can be used in a variety of ways – for examining data, for example, or writing an evidence-based opinion. For this activity, use it to summarize the published article.

   When writing a summary, it should be directed toward imagined readers who have not read the article being summarized, but have some familiarity in the topic area. (Students might think of this person as one of their peers.) The purpose of the summary is to give these persons a clear overview of the article's main points. The criteria for a summary are (1) accuracy of content, (2) comprehensiveness and balance, and (3) clear sentence structure with good transitions.

   What a summary *does not* include is the student's opinion on the author's writing style, the validity of their evidence, or anything else that is subjective. Students may benefit in knowing that "microthemes" are an excellent way to chronicle the literature they have read over time, as well as build annotated bibliographies.

[1] See John C. Bean, Dean Drenk, and F.D. Lee, "Microtheme Strategies for developing Cognitive Skills," in *Writing across the Curriculum: A Critical Sourcebook.* Eds. Terry Myers Zawacki and Paul M. Rogers. New York: Bedford St. Martin's, 2012. 146 – 157.

Extension activities

Vocabulary Worksheet

Below are a list of terms and phrases that you will encounter while reading the article and listening to the interview. Using a dictionary, provide definitions for each term or phrase. If you cannot find a formal definition, write down what you *think* the term or phrase might mean. Keep in mind that the meanings of these terms *in science* may be different from the way we used them in common speech. *Most likely definitions provided in blue.*

Genome

The complete set of genes that are contained within the cell of an organism.

Hot spot (in terms of genetics)

A specific region on a genome where a lot of change has occurred.

Allele

When a gene for a specific trait undergoes mutation, it can result in multiple forms of the same gene. For example, the gene for eye color has 4 alleles: "B" for brown, "b" (recessive) for blue, "G" for green, and "g" (recessive) for hazel. These different variants are called alleles and depending on how they are passed to the next generation (e.g., BB or Gg) determines what eye color presents.

Genetic Drift

Variation of particular genotypes in a population. Genetic drift takes into account genes that disappear because an individual possessing them dies or does not reproduce.

Divergence

When a population's gene pool separates from other gene pools through mutation, selection, etc. This can eventually lead to New sub-species and species.

Mutation

A permanent change that takes place in the DNA sequence of a gene and is not commonly found within a population.

Polymorphism

Occurring in several different forms. In genetics, DNA sequence variation that is common within a population.

Targeted NGSS, Cross-Cutting Concepts, and Science and Engineering Practices

The activities in this guide can be used to address the following standards, concepts, and practices.

Next Generation Science Standards	
LS3.A: Inheritance of Traits	• Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1)
LS4.A: Evidence of Common Ancestry and Diversity	• Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (HS-LS4-1)
LS4.B: Natural Selection	• The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3)
Science and Engineering Practices	
Developing and Using Models	• Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Obtaining, Evaluating, and Communicating Information	• Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).
Engaging in Argument from Evidence	• Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
Cross-Cutting Concepts	
Structure and Function: The way an object is shaped or structured determines many of its properties and functions.	• The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.
Patterns: Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them	• Empirical evidence is needed to identify patterns. • Mathematical representations are needed to identify some patterns.