THIS WORLD OF HUMANS

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This World of Humans: Episode #1
Guide for Educators

Junk DNA

These activities address NGSS LS1.A, LS3.A, and LS3.B, as well as specific Cross-Cutting Concepts and Science and Engineering Practices (see page 6). Many are also suitable for courses designated as "Writing-Intensive."

About the Article

This article builds on existing scholarship in the structure and function of genomes and presents a model for identifying how much of the human genome serves a functional purpose. The article helps explain why the functional genes within the human genome are limited, while the remaining "junk" DNA may be important for future functions. Importantly, it examines the critical role genetic mutation plays in survival of a species.

About the interview

In this interview, Dr. Graur explains what we mean by "junk" DNA and the ways in which DNA sequences are or are not important to current genomic function. The interview also explores the ways in which foreign DNA from viruses, etc., can "invade" the human genome.

Both the article and the interview can be found here: https://www.visionlearning.com/en/twoh/#ep1

Recommended: pair these materials with *Population Genetics*. For students needing a refresher on DNA, the Visionlearning series DNA I, II, and III are also useful accompaniments.

Use in the Classroom

These materials are useful for exploring how scientists use non-human communities to understand human ones. They also assist in building understanding of the different ways in which scientific information can be conveyed depending on audience. Students should read the article before listening to the interview.

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.

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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. **Science communication and persuasion**: Though many students and scientists alike believe that scientific discourse is antiseptic and free from arguments and other persuasive elements, nothing could be further from the truth. Science has its own rhetoric that shapes the ways in which individuals read and believe content. "Rhetoric" is not malicious, however. It simply means a way of communicating (in text and visuals) meant to convince a reader. This activity prompts students' thinking about what they subconsciously already know about the rhetoric of science. The activity requires a chalk- or white- board and writing implements (chalk or dry erase markers). The worksheet on page 5 can be used in conjunction or separate from this activity and explores rhetorical appeals in greater detail. ***Example instructions to students:***

   We are going to do a brainstorming activity together on the board. Here are our steps:
   1. *Brainstorm on paper: What information in scientific research convinces you that the research is solid and unbiased? Another way to think of this: How do you know a scientist is credible?*
   2. *What qualities of a research presentation (a paper, talk, or poster) make you* question *the results of the research?*
   3. *When you are ready, begin writing your ideas on the board. Whenever possible, connect them similar ideas posited by others.*

   In scientific communication, features that tend to persuade are the use of citations, jargon, visuals, presentation of data, use and explanation of statistics, etc. Things that dissuade/cause the author to lose credibility include flowery language, overly long and complex sentences, claims without support (lack of citations or data), and unfounded disparaging remarks about other scientists' research. Prompt students to think of scientific rhetoric as they read the article and listen to the interview.

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. **Outlining to understand the structure of the article:** Scientific articles can be very hard to understand the first time reading. One activity that can be very helpful is to create a reverse outline of the piece to see how it is structured and how the individual parts fit together as a whole. This activity has two steps. The first is for each student to outline the article alone. The second is to compare their outline to another student or in small groups. ***Example instructions to students:***

   Step 1: The Outline

   - *Create an outline of the overall structure of the piece. Start by identifying the headings used by the author, then any subheadings.*
   - *Next, move paragraph by paragraph and identify the strategies and sentence structures the author uses to make you believe their ideas. Note these in your outline.*
   - *Identify how the author is synthesizing the research. Look at the actual mechanics of the sentences. How is the information presented? Is he using more than one source to support his ideas? How is he doing this?*

- *In each major section of the paper, find two or three sentences that include citations of previous research. How are the citations used in different section of the paper? Look for citations that support qualifications, explanations, or justifications made in the text. What other functions do citations serve in the text?*
- *When done, note any patterns that you see within or between sections.*

Step 2: Revisit the Outline

- *Compare your outline with another person.*
  a. *What is similar? What is different?*
  b. *What strategies and structures does the author use? Which were particularly convincing?*
  c. *How did the author summarize and synthesize the literature?*
  d. *Did you notice any patterns?*

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. Here are some questions that are appropriate for use with the learning module *Population Genetics.* ("**VL**" denotes that the question refers to Visionlearning modules.)

   - **(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 have an effect on the functional portion of the human genome. Can you find examples in Graur's paper as to what they might "look" like in practice?*
   - **(VL)** *What reasons do Graur and Warmflash and Lents offer for why "harmful" alleles may remain in populations?*
   - *In the interview, Graur explains that having more genes does not necessarily mean that a genome has more complexity – it means that we do more with a limited amount of genes. In your own words, explain what he means.*
   - *If you completed the "persuasion" activity, discuss how Graur is or is not convincing you that his research is credible. What does he include or not include? If you were a peer reviewer of this article, what questions would you have for him or what would you ask him to revise?*
   - *In the podcast interview, Graur comments that there are two groups of genes – those where the precise sequence of DNA is important, and those where the sequence is* not *important. Explain what he means by this claim and why it is important.*
   - *Using common, everyday language, explain Graur's research and findings.*

4. **Make a scientific poster**: Research posters are very common in the sciences. They offer all members of the scientific community – from novice to expert – an opportunity to present early research and to talk one-on-one with other members of the scientific community who may be interested in the poster's topic. Like the scientific paper, the poster follows a similar format of Introduction, Methods and Materials, Results, and Discussion. In this activity, task students with creating a poster based on Graur's paper. They may elect to use information from the interview to supplement the poster, and will likely need to create imagery from scratch. PowerPoint and free online design software is useful for this activity. This project will take considerable time (a few hours outside of class) and, with large classes, is suitable for student pairs. Use a class session to explore the different ways students chose to organize and present the data.

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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.

Mean Fitness

From Northwestern University: "The sum of the fitnesses of the genotypes of a population weighted by their proportions; hence a weighted mean fitness."

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

Changes in the abundance of particular alleles or genotypes in a population by random chance (as opposed to natural selection).

Genetic Load

"The presence of unfavorable genetic material in the genes of a population." (Merriam Webster)

Mutational Load

From Blackwell Publishing: "the total genetic burden in a population resulting from accumulated deleterious mutations. It is a kind of genetic load. It can be thought of as a balance between selection against a deleterious gene and its production by mutation."

Deleterious Mutation

A genetic mutation that is harmful rather than beneficial to the organism and/or population.

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Reading Guide and Worksheet:

This worksheet is meant to help you delve deeper into the ways in which scientists use language in scientific articles – in this case, genetics. Below is some information about the different rhetorical moves scientists often use when presenting research. Using this as a guide, examine the article to identify at least 3 moments where the authors are doing these things.

Definition	How does the author use each of these (if they do) to develop their purpose?
Ethos: Ethical appeals establish the credibility and goodwill of the author or of the sources used to support an argument. Where and how does the author explain his or her related background or establish the credibility of the sources used? (Hint: This is not always in the text proper. Consider all of the material on the page.)	*Students should for the ways scientists establish credibility. Apart from affirmative statements, this includes the use of citations, statements about ethics, institution affiliations, whom they 'thank' in the acknowledgements, who funded the research, etc. Within the text proper, students might look to the data set the authors draw on and their methodological rigor.*
Pathos: Emotional appeals draw on the readers' emotional response to the subject and on shared beliefs and values. This doesn't always mean *creating* feeling – it can be an absence of feeling, as well. Where does the author use language and/or create images that are emotionally charged? (Hint: Look for descriptive terms and words that have positive or negative associations.)	*Appeals to emotion tend to occur in the introduction and discussion sections of scientific articles. Here, where the text tends to be more expository, students will find adjectives like "critical" and "more important," "hallmark" and "gregarious". They will also see it in clauses and phrases – e.g., "must be established."*
Logos: Logical appeals use reasoning and evidence in support of an argument. Logical appeals draw on facts, statistics, research, financial costs, observations, and experiments to reach conclusions using logical schema. Where and how does the author use evidence? What kinds of evidence are used? What logical schema does the author draw on to interpret the evidence?	*Like ethos, this can include the use of other sources/research to support their claims, or to highlight where the other research went astray. More often, though, logos is used within the "Methods" and "Results" section of scientific articles, where the text focuses heavily on the presentation of data. This includes statistics, tables, figures and graphs, diagrams, etc. It also can be demonstrated in discussions of the significance of the research (e.g., who it will help, how many lives saved).*

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	
LS1.A: Structure and Function	• All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1) (secondary to HS-LS3-1)
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)
LS3.B: Variation of Traits	• In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)
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.
Analyzing and Interpreting Data	• Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
Cross-Cutting Concepts	
Structure and Function: The way an object is shaped or structured determines many of its properties and functions.	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • 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.