My DNA is Full of Junk!

Developed for the Carnegie Science Center, Pittsburgh PA

GRADE LEVELS

- 7-10: Use this activity to make a complex topic more understandable and relevant to your students.
- 12: Use a simple activity to introduce complex topics about the elements of DNA before beginning a more challenging lesson about these components.

TIME OF ACTIVITY

- 20-30 minutes (depending on complexity of your corresponding lesson)

LEARNING OBJECTIVES

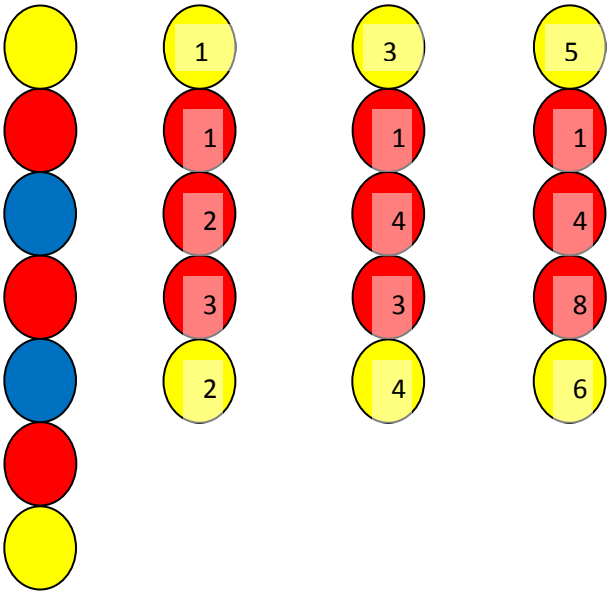
- Junk DNA, introns, and exons are all important elements of DNA/RNA.
- DNA is like a tool kit! The cell transcribes DNA into RNA which is translated into proteins.
- After a cell makes RNA from DNA, introns are removed to create mature RNA.
- Elements of DNA that serve a purpose in the organism appear to be conserved evolutionarily.
- Scientists compare introns and exons to determine relatedness.
- Junk DNA is usually not involved in the process of determining relatedness since it is so random and repetitive.

MATERIALS

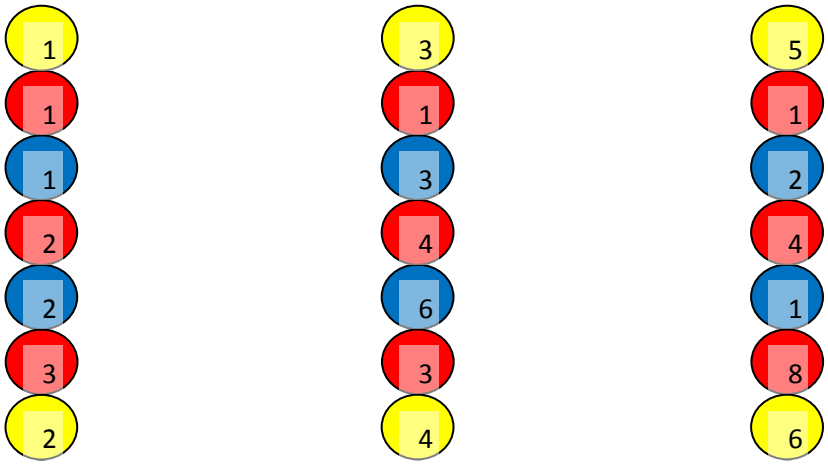
- Marker or adhesive stickers for labeling the beads in preparation for the activity
- Pop-Together beads in 3 different colors to represent introns, exons, and junk DNA. Need 8 of color 1, 12 of color 2, 8 of color 3. (example link: http://www.toysandgamesonline.com/asp/show_detail.asp?sku=EDS1137&refid=FR96-EDS1137)
- Sign describing these 3 elements of DNA

PREPARATION

- Using a marker or adhesive stickers, label the following directly on the linking beads:
  - Color #1 (yellow, as shown here): 1, 2, 3, 4, 5, 6
  - Color #2 (red, as shown here): 1, 2, 3, 1, 4, 3, 1, 4, 8
  - Color #3 (blue, as shown here): 1, 2, 3, 6, 2, 1
  - Unlabelled: 2 beads of Color #1, 3 beads of color #2, and 2 beads of color #3 should remain UNLABELLED!
- Use the labeled linking beads to make the following structures:



  - Labeled beads 1, 2, 3, 6, 2, 1 from Color #3 should be set aside to be "popped back in" later in the lesson plan. This set-up is shown here, although it will not be done until later:



TAKE-HOME MESSAGE

Different organisms, across numerous species and lineages, can have the same sequences of introns and exons. These sequences are shared because they evolved in a common ancestor. Because the sequence was useful to the organism it was kept throughout the evolution of the species.

IMPORTANT BACKGROUND INFORMATION

Every organism has DNA, and its DNA contains all needed instructions for the life of the organism. DNA is made of intron, exon and junk sequences. Exons are code for proteins and introns are believed to play an important role in regulating protein production.

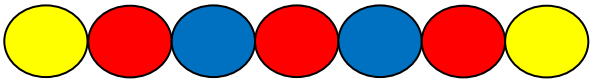
For a cell to make a protein, it will create RNA from DNA in a process called transcription. Introns, exons, and junk DNA are all transcribed from DNA to the first "draft" of RNA, called pre-mRNA. This molecule is spliced to become mature mRNA or RNA. Splicing is a step where introns are removed. Exons remain to be translated into proteins. Junk DNA is often replicated as well, and is not spliced out like introns.

Different organisms, across numerous species and lineages, share sequences of introns and exons. These sequences are shared because they evolved in a common ancestor. Because the sequence was useful to the ancestor organism it was kept throughout the evolution of the species.

ACTIVITY

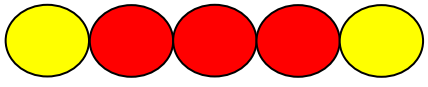
Part #1

1. Tell your students that DNA has three elements: Introns, exons, and junk DNA. All three are used to make a message called RNA. RNA is what is used to make proteins.
    - Show the following piece of DNA:



Junk DNA Introns Exons

2. But, something happens before the RNA is ready to make proteins: the introns are removed. Junk DNA is often replicated as well into proteins, and is not spliced out like introns.
    - The student can remove the introns from the RNA, leaving the exons and Junk DNA.



    - This RNA is used to make proteins that go on to make all the different parts of a cell and to help govern all the different processes in a cell.
3. Discuss the elements of DNA
    - Junk DNA
        1. What do you think Junk DNA means? (It's exactly like it sounds!)

2. 95% of human genome is Junk DNA; have no known function, usually random repeating sequences; can be important for evolution (provides a pool for new genes to come out of)

- Have you ever heard of introns and exons?
  1. Introns are removed from RNA and not translated into proteins. Introns are important because they perform regulatory functions. This means that introns help the cell know when to make proteins and when to stop, even when to duplicate the whole DNA, etc.
  2. Exons – This is the information that the cell uses to make proteins.

Part #2 – DNA and Evolution

1. Show 3 sequences of RNA, without any introns, from 3 different organisms: The colors, like in Part #1, indicate the element type, while the numbers are specific to the sequence at that region.

ORGANISM A:

ORGANISM B:

ORGANISM C:

2. Ask: Do you notice anything similar or different between these 3 organisms?
   - They all contain regions of junk DNA (now RNA) and exons. Some of the regions are the same and some are different!)

3. What do you think it means if the organisms have the same or different numbers on their exons or introns?
   - Exons with the same number means that two organisms share the same exon.

4. Ask: How many exon sequences are in common between A and B? Between A and C? Between B and C?

5. Why do you think exons can be found across different species but the junk RNA is always different?

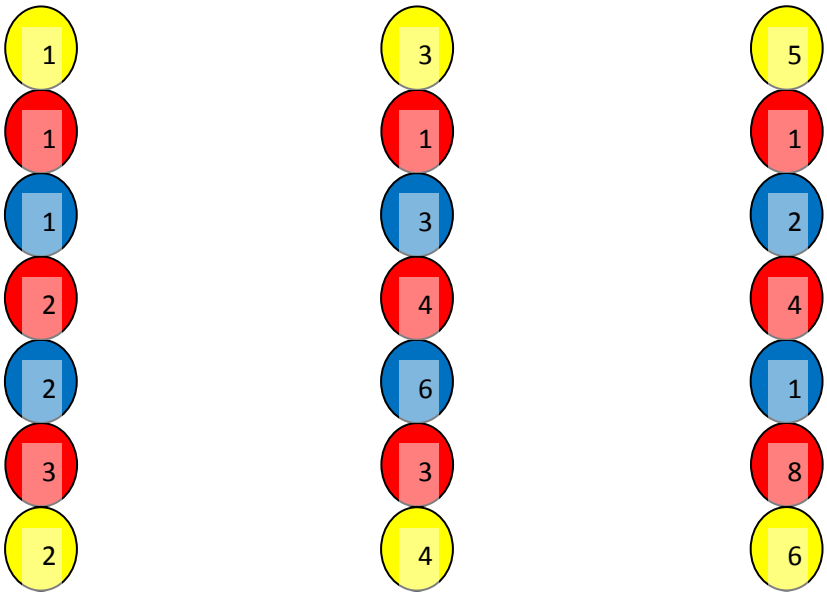
- Junk DNA is usually not conserved between organisms of the same or different species because it is so random and repetitive! None of these organisms have common junk DNA sequences!
- Exons are useful sequences, they make proteins. These organisms must descend from a common ancestor that had the exons in question. As the different species evolved, they kept the exons because they were useful.

6. Organisms that share a more recent common ancestor are said to be more closely related.
   - Ask: By looking at this information, which organisms appear to be the most related?
   - Discuss: When looking at only the exon and junk DNA sequences, it would seem that Organisms A and B or Organisms B and C would be more related than Organisms A and C.

7. Ask: Do you think your conclusions may change once you look at the original sequence of DNA that contained the introns? (Pop the introns back into the sequences – see "preparation".) Let's find out!

8. Make the following sequences to represent the DNA from the 3 organisms:

ORGANISM A: ORGANISM B: ORGANISM C:



9. Ask: What similarities and differences do you notice now?
   - Help students note that introns and exons are sometimes shared, but junk DNA is never shared.
   - Ask: Why do you think that it is important to look at the intron and exon sequences?
   - When attempting to find the common ancestor or determine relatedness between species both are important to look at. Let's continue to find out why!

- Ask: How many intron sequences are shared between A and B? Between B and C? Between A and C?
- Ask: Which organisms share the most DNA sequences?
    - Discuss: Now it should be Organisms A and C!

10. Ask: What does this tell you about the importance of introns for the organism?
    - Introns must serve an important function! Introns help regulate the production of proteins. This intron probably evolved in a common ancestor of the two species. Because the intron was useful as these species evolved, they still kept the intron. So Introns tell us important evolutionary information about an organism and species, even though introns are not translated into proteins.
    - Discuss: Because introns do not have as many mutations, etc. (since they do not go through all of the translation that exons do), they carry more "accurate" genetic information. Do you think this would make them more or less reliable indicator than exon sequences alone?

11. Ask: How have your thoughts changed after looking at the introns and the exons?
    - The conclusions are probably different now. This is why scientists look at both exons and introns when trying to figure out how closely related two species are.

12. Ask: What did you notice about the Junk DNA sequences? Did they seem important at all when comparing relatedness? Why or why not?
    - Junk DNA is not very conserved so it is thought to not be very useful to the species. Therefore it is not used for evolutionary comparison. Although scientists continue to study why it is so prevalent in some species and much rarer in others.