



MYSTERIES OF REPETITIVE DNA SEGMENTS

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YOUNG REVIEWERS:



ALMA

AGE: 12



BASSAM

AGE: 15



BATOUL

AGE: 10



MARIE-
LOUISE

AGE: 11



TAMAM

AGE: 15

The total DNA of an organism is called the genome. DNA contains all the instructions for how to build an organism and how that organism will function. Some DNA sequences are repeated thousands and thousands of times throughout the genome. Repeats lined up one after another are called satellite DNA. The number of copies of a given satellite DNA sequence can rapidly change, and differ among individuals. Although satellite DNAs were once considered useless, researchers are continuously discovering their important roles in various organisms. Satellite DNAs are essential for keeping organisms functioning properly. They help cells divide and keep the genome integrity. They can affect behavior, health, and help the organism to overcome stressful conditions. In these ways, satellite DNAs increase Earth's biodiversity.

BIOLOGICAL INFORMATION

DNA molecules are the carriers of biological information. DNA contains instructions for how the bodies of every life form, including ours, will develop and function. Children inherit DNA molecules from their parents. How is information “written” in the DNA? Each DNA molecule is built of two strands, wrapped around each other. Strands are made up of compounds called nucleotides. Each nucleotide consists of a phosphate group, a five-carbon sugar, and a nitrogenous base. There are four bases, with names commonly shortened to A, T, G, and C. The order of bases codes for the information carried by the DNA molecule. This sequence is specific for every life form that lives or has lived on Earth. Thus, DNA is the basis of **biodiversity**.

BIODIVERSITY

The diversity of all living organisms on Earth, including their differences at the species level, the genetic variation within species, and the different environments they inhabit.

GENOME

The complete DNA content of an organism.

SATELLITE DNA

Segments of the DNA molecule repeated one after the other.

DNA SEQUENCING

The laboratory process of determining the order of nucleotides in DNA.

WHAT IS A GENOME?

The total DNA of an organism is called the **genome** (Figure 1A). Segments of a genome carrying information for specific characteristics are called genes. For example, genes define the color of a plant’s flowers and your body’s blood type. That is why genes are of interest for many scientists. However, genes usually make up less than 2% of a genome! The rest, 98% of the DNA, was a mystery for a very long time. It was originally thought to be meaningless, but scientists have discovered that it is not! In these mysterious parts of the genome, different types of DNA can be found. For example, transposons, which are DNA segments that can jump to other locations within the genome (if you wish to learn more about transposons, please check out [this Frontiers for Young Minds article](#)). Another type of sequences in these mysterious regions are called **satellite DNAs**, which we will discuss next.

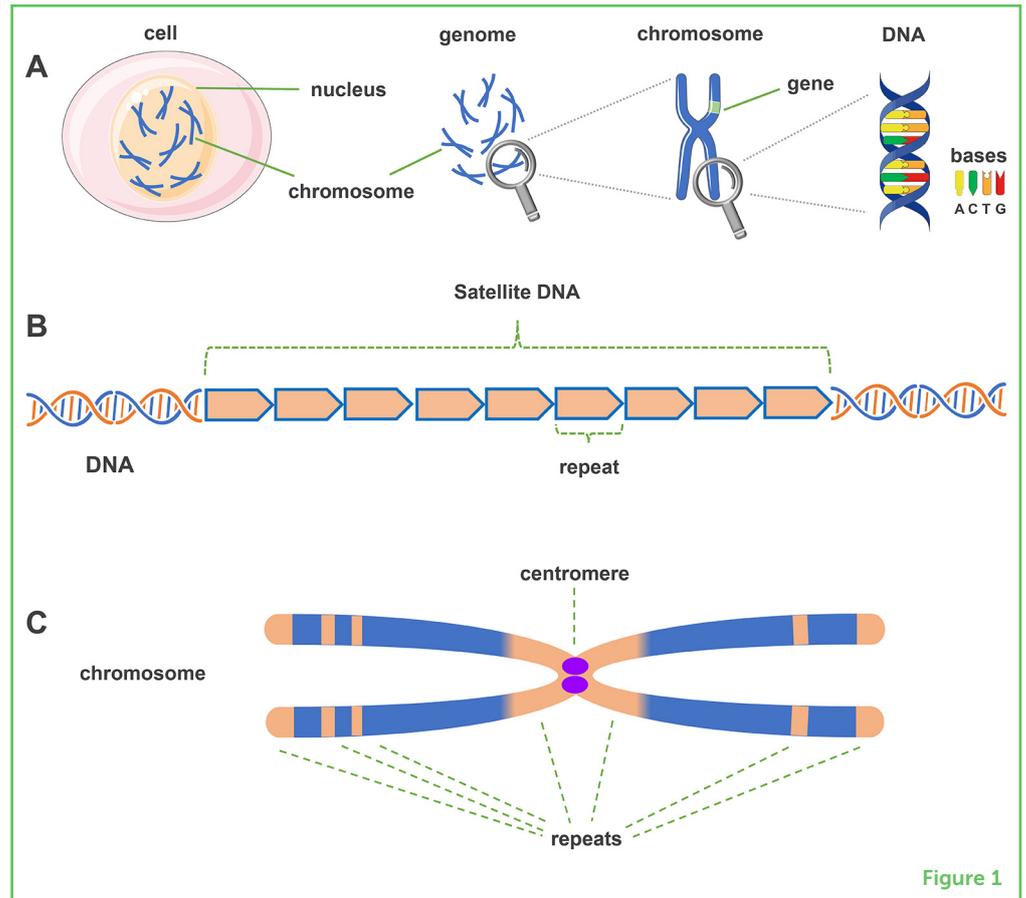
WHAT IS SATELLITE DNA?

Satellite DNA consists of DNA segments that are repeated many times, one after the other (Figure 1B). Their name originates from early DNA experiments back in the 1960s. In those experiments, when the DNA of an organism was isolated in a lab, it often appeared separated into two components: the main one and an accompanying component—the “satellite” DNA. In the “satellite” component, DNA segments are repeated one after the other.

There are many different satellite DNAs. Each satellite DNA has its own repeating unit. Its copies can be repeated many thousands of times in a single genome. Satellite DNAs may look like the most boring components of the genome. But as we will see, they are not! Scientists have learned much about the important roles of these mysterious sequences. Our knowledge about satellite DNAs has advanced rapidly in recent years, thanks to the invention of novel methods of **DNA sequencing**. Still, there is a lot yet to be learned about satellite DNA!

Figure 1

(A) From left to right: cell with chromosomes in the nucleus. The DNA of all chromosomes makes up the genome. A gene is a specific piece of a chromosome. DNA contains a sequence of nitrogenous bases, A, T, C, and G. (B) Satellite DNA segments repeated one after the other. (C) In a chromosome, arrays of satellite DNAs can be grouped in key locations: within and surrounding the centromere (the region involved in separation of genetic material during cell division), at chromosome ends, and at various locations along the chromosomes.

**Figure 1**

EVOLUTION BOOSTERS

One feature is characteristic of all DNA sequences repeated in a row: they are the most rapidly changing genome components. How do they succeed in this? Cellular mechanisms can rapidly change the length of arrays by adding or removing repeat units. One satellite DNA can become dominant over the others by obtaining new copies of repeat units. Some satellite DNAs may lose their repeats or even disappear. What are the consequences? Changes in copy numbers of satellite DNAs can reshape the genome. Each life form has its own composition of satellite DNAs. Changes in satellite DNAs can promote genome evolution and contribute to biodiversity [1]. Next, we will tell you how they do it!

DISTRIBUTION CENTERS OF THE CHROMOSOMES

Satellite DNAs are clustered at crucial points within the genome. Chromosomes are tiny structures within the cell, into which DNA molecules are packed (Figure 1A). When cells divide, chromosomes must be separated into each of the new cells. This is done by a complex protein structure built on a segment of DNA. This part of the chromosome is called the **centromere** (Figure 1C). Satellite DNAs are common components of the centromere [2]. They help cells to equally distribute genetic material

CENTROMERE

The region of the chromosome involved in the separation of genetic material during cell division.

during division. Failures in this process result in serious problems for the cell and the whole organism.

GUARDIANS OF THE CHROMOSOME ENDS

Another favorite location of satellite DNAs is at the ends of chromosomes. There, repeated units protect DNA molecules. This is necessary because DNA ends can be easily degraded. The degradation could continue and endanger the entire genome. Lost repeated units can be replaced by new ones to keep the DNA molecule stable. However, loss of repeats ultimately occurs as humans age. Newborn babies have full-length chromosome ends. The older we are, the shorter the ends. Regulating the number of repeats at DNA ends is essential for the functioning of the genome.

STRESS RESPONDERS

Satellite DNAs respond to stressful conditions. Stress can be caused by environmental changes, exposure to toxic chemicals, or other factors. Scientists have observed that satellite DNAs can help protect organisms from stress. Satellite DNAs are usually tightly packed with the help of special proteins. Such tight packing turns off many processes, and gene activity near satellite DNAs is changed [3]. When cells are under stress, complex mechanisms based on satellite DNA repeats are activated or silenced. This way, satellite DNAs can help the organism regulate many processes and survive unfavorable periods.

IDENTITY CARDS

Satellite DNAs with very short repeat units are often called **microsatellites**. Many different microsatellites are scattered throughout our genomes. The lengths of their arrays are unique for each individual, creating what is known as our **DNA fingerprint**. Each person has a combination of arrays inherited from their parents. Determining a person's DNA fingerprint is relatively simple. It can be done as an everyday routine in laboratories.

There are different practical uses for DNA fingerprints. Microsatellite profiles are used in **forensics**. Forensics uses science to solve crimes by carefully studying evidence. DNA fingerprints can help match the DNA found at a crime scene to that of a suspect in a police investigation. Microsatellites are also helpful in figuring out whether two people are related. This is done by comparing their microsatellite profiles.

MICROSATELLITES

Repetitive DNA with very short repeat units.

DNA FINGERPRINT

The unique DNA pattern in each individual.

FORENSICS

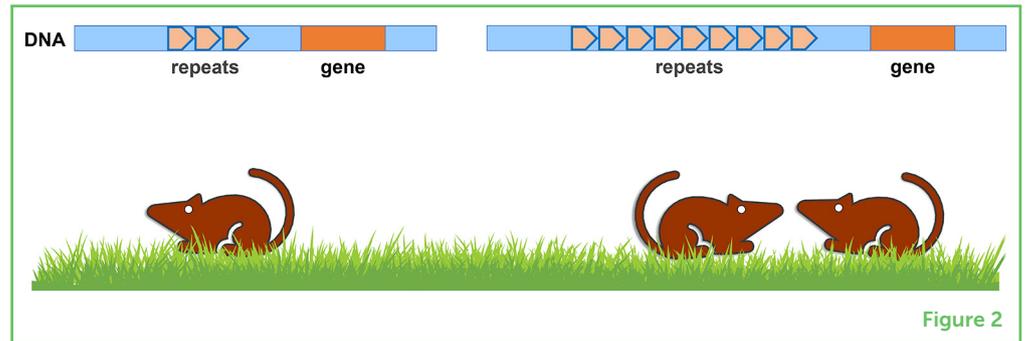
Scientific tests or techniques used in crime detection.

BEHAVIOR INFLUENCERS

Microsatellites can change brain activity and how animals behave socially. They can cause voles (small rodents) to interact differently with other voles [4]. For example, some voles are more social and likely to form close bonds with other voles, while others are not as social. Behavior of voles depend on the number of repeats in front of one gene. This gene affects how animals feel about bonding and being social. If the number of microsatellite repeats in front of the gene is bigger, the voles are more social (Figure 2).

Figure 2

The social behavior of voles depends on the number of microsatellite repeats in front of one gene. The more repeats, the more social the voles are.



COPY NUMBERS AND DISEASES

Scientists have observed that the number of repeats of some human satellite DNAs is changed in certain diseases [5]. We know that satellite DNAs influence gene activities. In some cases, a disease is caused by an increase in the copy number of repeated units at a certain location in the genome. In other cases, a disease is caused by the decrease. What can we conclude? The numbers of repeats can be markers of some diseases. Changes in array length can also predict how serious symptoms will be. Understanding changes in satellite DNAs is important for understanding the mechanisms that keep our bodies healthy.

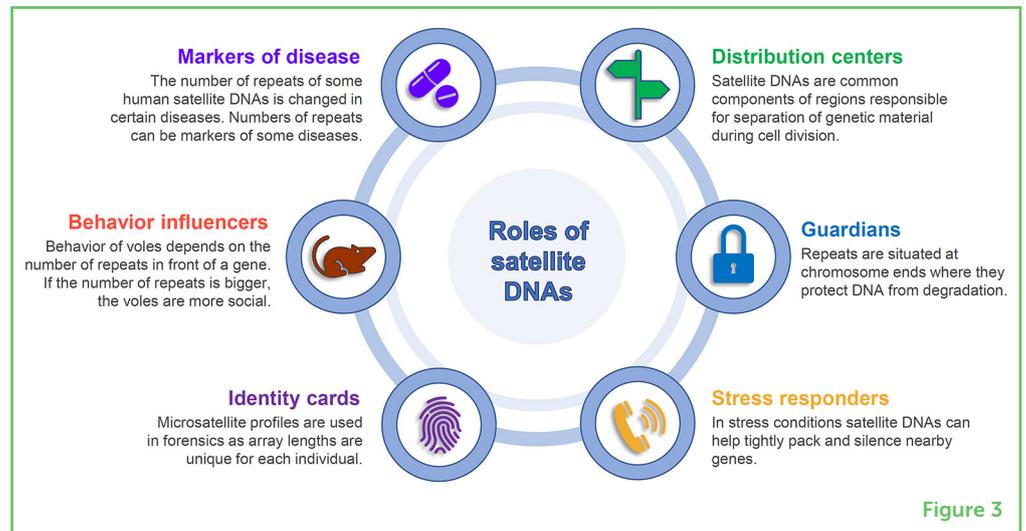
WHAT HAVE WE LEARNED?

Satellite DNAs are segments of DNA repeated many times, one after the other. They differ in DNA sequence, repeat unit length, number of copies, and locations within the genome. They occupy regions responsible for properly distributing DNA during cell division, and they keep the ends of DNA molecules safe from breakdown. Differences in copy numbers of some repeats among individuals are used as “DNA identity cards”. Satellite DNAs can reshape the genome and enhance biodiversity by changing the number of repeated sequences. Copy number changes in some satellite DNAs are found during aging, stress, and disease, and they can influence an organism’s behavior. Satellite DNAs help to keep genes—and the whole organism—functioning properly. They also help organisms resist stressful environmental changes. Through all these functions (Figure 3), satellite

DNAs help enhance or preserve biodiversity. Many roles of satellite DNAs are certainly still waiting to be discovered!

Figure 3

Contributions of satellite DNAs to genome structure and functioning.



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REFERENCES

- Šatović-Vukšić, E., and Plohl, M. 2023. Satellite DNAs – from localized to highly dispersed genome components. *Genes* 14:742. doi: 10.3390/genes14030742
- Plohl, M., Meštrović, N., and Mravinac, B. 2014. Centromere identity from the DNA point of view. *Chromosoma* 123:313–25. doi: 10.1007/s00412-014-0462-0
- Ugarković, Đ., Sermek, A., Ljubić, S., and Feliciello, I. 2022. Satellite DNAs in health and disease. *Genes* 13:1154. doi: 10.3390/genes13071154
- Hammock, E. A. D., and Young, L. J. 2005. Microsatellite instability generates diversity in brain and sociobehavioral traits. *Science* 308:1630–4. doi: 10.1126/science.1111427

5. Liao, X., Zhu, W., Zhou, J., Li, H., Xu, X., Zhang, B., et al. 2023. Repetitive DNA sequence detection and its role in the human genome. *Commun. Biol.* 6:954. doi: 10.1038/s42003-023-05322-y

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YOUNG REVIEWERS



ALMA, AGE: 12

Hi! I am Alma, 12 years old. I love mathematics and enjoy solving problems and thinking logically. I am also passionate about science, especially robotics. Two years ago, I took a robotics course that increased my interest and understanding. Outside of academics, I enjoy playing tennis and reading, it helps me stay active and focused. I consider myself a creative person who is always ready for new challenges and learning opportunities. I strive to grow and enjoy every step of the journey.



BASSAM, AGE: 15

Hello, I am Bassam, a 15-year-old student with a strong passion for science and innovation. I am especially interested in how medicine, biotechnology, and engineering come together to solve real-world health problems. My goal is to one day work at the cutting edge of medical technology, creating solutions that improve lives and advance modern healthcare.



BATOUL, AGE: 10

Hi! I am Batoul, 10 years old. Reading novels is my favorite thing to do. I love the color white it makes me feel calm. Books take me into new and exciting worlds. I love writing; it lets my thoughts fly free. I enjoy quiet moments and big ideas. Every day, I learn something new.



MARIE-LOUISE, AGE: 11

My name is Marie-Louise (Izzy) and when I grow up I want to be a marine biologist. I have a pet tortoise named Heinz, like the ketchup and other sauces brand. For three years I have been living by the sea and already written two articles one of which was published on oceanographic magazine, [Here](#). Besides marine biology I like STEM, skateboarding and maths.



TAMAM, AGE: 15

Hello, my name is Tamam. I am 15 years old. I enjoy reading and asking questions to expand my knowledge. I also love biology. I am looking forward to expanding my knowledge of health sciences.

AUTHORS



EVA ŠATOVIĆ-VUKŠIĆ

I am a molecular biologist working as a researcher at Ruđer Bošković Institute in Croatia. My primary research focus revolves around the repetitive DNA sequences in the genomes of various organisms. I have characterized a broad range of transposable elements and satellite DNAs, and investigated their structure, function, localization, organization, evolution, and influence on the overall architecture of the genome. Repetitive sequences like satellite DNAs and transposons were once accused of being “junk DNA”, with no relevant biological function. This has been proven very wrong and I enjoy contributing to the debunking of this myth.

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MIROSLAV PLOHL

I am a senior scientist at Ruđer Bošković Institute in Zagreb, Croatia, emeritus of the Institute since 2022. For over 30 years, I focused on exploring the structure and evolution of non-coding repetitive DNA sequences that build the major fraction of our genomes. My main goal is helping people to understand the usefulness of these sequences, particularly, by explaining their functions. I was principal investigator or participant in many projects that included international collaborations with scientist with similar interests.