OPEN ACCESS Freely available online

Immunogenetics: Open Access

Opinion Article

Understanding Codominance and Its Role in Traits, Blood Groups, and Genetic Diversity

Ari Carter*

Department of Immunology, University of Cambridge, Cambridge, United Kingdom

DESCRIPTION

Genetics is often introduced through simple ideas of dominant and recessive traits, where one gene masks the expression of another. However, real biological systems are far more complex and interesting. One such example is codominance, a form of inheritance in which both alleles in a gene pair are fully expressed in the phenotype of an organism. Instead of one trait overpowering the other, both traits appear simultaneously and visibly. Codominance challenges the oversimplified view of genetics and reveals how diversity in traits arises naturally in living organisms.

In codominance, neither allele is recessive or dominant. Instead, both contribute equally to the observable characteristics of the organism. This means that when an individual inherits two different alleles for a particular gene, both are expressed without blending or suppression. This is different from incomplete dominance, where traits mix to form an intermediate phenotype. In codominance, both traits remain distinct and clearly visible.

A classic and widely studied example of codominance is the human ABO blood group system. In this system, the alleles IA and IB are codominant. When a person inherits IA from one parent and IB from the other, both alleles are expressed equally, resulting in blood type AB. Individuals with blood type AB display both A and B antigens on the surface of their red blood cells. This clear expression of both traits makes the ABO system one of the most important real-life examples of codominance in human biology.

The ABO blood group system also highlights the medical importance of codominance. Blood transfusions depend heavily on compatibility between donor and recipient blood types. Because individuals with AB blood express both A and B antigens, they can receive red blood cells from any ABO group, making them universal recipients in terms of red cell transfusions. Understanding codominance in this context has saved countless lives and remains a fundamental principle in transfusion medicine and organ transplantation.

Codominance is not limited to humans. It is widely observed in plants and animals as well. In certain cattle breeds, for example, coat color exhibits codominance. When a red-haired cattle breed is crossed with a white-haired breed, the offspring may show roan coloration, where both red and white hairs appear together distinctly rather than blending into a pink or intermediate shade. This visible side-by-side expression of both parental traits is a clear demonstration of codominance in nature.

In chickens, codominance can be seen in feather patterns as well. When a black-feathered chicken is crossed with a white-feathered one, the offspring may display both black and white feathers simultaneously, rather than a gray or blended color. These examples in animals help scientists and students understand that codominance is a natural genetic mechanism that contributes to variation within species.

At the molecular level, codominance occurs because both alleles produce functional gene products, such as proteins, and neither interferes with the other's expression. As a result, both traits are independently visible in the organism. This differs from dominant-recessive inheritance, where the dominant allele produces a functional product that masks the effect of the recessive allele, often because the recessive allele produces a non-functional or less effective protein.

The study of codominance is important in genetics because it helps explain the complexity of inheritance patterns beyond simple Mendelian laws. Gregor Mendel's early experiments with pea plants established the foundation of genetics, but codominance shows that not all traits follow strict dominant-recessive relationships. Instead, multiple genetic interactions contribute to the diversity of life forms seen in nature.

Codominance also plays a role in evolutionary biology

By allowing both alleles to be expressed, codominance increases genetic variation within populations. This variation is essential for natural selection, as it provides a wider range of traits that may be advantageous in changing environments. Populations

Correspondence to: Ari Carter, Department of Immunology, University of Cambridge, Cambridge, United Kingdom, Email: carter@gmail.com

Received: 22-May-2025, Manuscript No. IGOA-25-41 828; **Editor assigned:** 26-May-2025, PreQC No. IGOA-25-41828 (PQ); **Reviewed:** 09-Jun-2025, QC No. IGOA-25-41828; **Revised:** 16-Jun-2025, Manuscript No. IGOA-25-41828 (R); **Published:** 22-Jun-2025, DOI: 10.35248/IGOA.25.10.262

Citation: Carter A (2025). Understanding Codominance and Its Role in Traits, Blood Groups, and Genetic Diversity. Immunogenet Open Access. 10:262.

Copyright: © 2025 Carter A. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

with greater genetic diversity are often more resilient to diseases and environmental stress.

In human health beyond blood groups, codominance can influence immune system function. Certain genes involved in immune response may exhibit codominant expression, meaning that both parental gene variants contribute to immune activity. This can affect how individuals respond to infections, vaccines, and even autoimmune conditions. Although these interactions are complex, they highlight how codominance contributes to biological individuality.

Despite its importance, codominance is often misunderstood by students because it does not fit neatly into simple inheritance charts. Unlike dominant or recessive traits, codominance requires careful observation of phenotypes rather than assumptions based on masking effects. Modern genetics education increasingly emphasizes real-world examples like blood groups and animal coat patterns to help learners grasp this concept more clearly.

CONCLUSION

In conclusion, codominance represents a fascinating and essential principle in genetics where both alleles are equally expressed without blending. From the ABO blood group system in humans to coat color patterns in animals, codominance plays a vital role in shaping biological diversity. It expands our understanding of inheritance beyond classical Mendelian genetics and reveals the complexity underlying even the simplest traits. As genetic research continues to advance, codominance remains a key concept in explaining how life inherits and expresses its vast range of characteristics.