

Click to verify



Emergent properties examples

What Are Emergent Properties?. A term used in science, systems theory, philosophy, urbanism and even art, "emergent properties" or "emergence" refer to those properties that arise from the collaborative functioning of a system, but do not belong to any one part of that system. Here are a few examples.The Brain - An old saying tells us that "the whole is greater than the sum of its parts". A fancier way of saying this is with the term emergent properties, a term used in science, systems theory, philosophy, urban studies and even art. "Emergent properties" refer to those properties that are entirely unexpected and include emergent phenomena in materials and emergent behavior in living creatures. They arise from the collaborative functioning of a system, but do not belong to any one part of that system. In other words, emergent properties are properties of a group of items, whether insects, atoms or buildings, that you would not find in any of the individual items. Examples of emergent properties include cities, the brain, ant colonies and complex chemical systems. Ant Colonies A single ant is a rather limited organism, with little ability to reason or accomplish complex tasks. As a whole, however, an ant colony accomplishes astounding tasks, from building hills and dams to finding and moving huge amounts of food.Video advice: Emergent Properties✓ and Other Emergent Properties in a Simple Biological System of MicrotubulesVassy J, Portet S, Bell M, Millot G, Fauvel-Lafeve F, Karniguan A, Gasset G, Irinopoulou T, Calvo F, Rigaut JP, Schoevaert D: The effect of weightlessness on cytoskeleton architecture and proliferation of human breast cancer cell line MCF-7. FASEB J 2001;15:1104-1106.References - In biological systems, emergent properties may develop due to numerous individual molecular elements in a population being strongly coupled in a non-linear manner. Under suitable conditions, the formation in vitroof a population of microtubules, a major component of the cellular skeleton (cytoskeleton), behaves as a complex system and develops a number of emergent phenomena. These preparations, which initially contain just two molecular species, a nucleotide and a protein, self-organize by reaction and diffusion and the morphology that develops is determined at a critical moment early in the process by weak external factors, such as gravity and magnetic fields. The process also results in other emergent phenomena, namely replication of form, generation of positional information, and collective transport and organization of colloidal-sized particles. Microtubules are responsible both for cellular organization and the transport of subcellular particles from one part of the cell to another.Video advice: Emergent PropertiesEmergent phenomena are all around us. They can be summed up as being more than the sum of their parts.Concepts: EmergenceEmergence refers to the existence or formation of collective behaviors — what parts of a system do together that they would not do alone. In describing collective behaviors, emergence refers to how collective properties arise from the properties of parts, how behavior at a larger scale arises from the detailed structure, behavior and relationships at a finer scale. For example, cells that make up a muscle display the emergent property of working together to produce the muscle's overall structure and movement. A water molecule has emergent properties that arise out of the properties of oxygen and hydrogen atoms. Many water molecules together form river flows and ocean waves. Trees, other plants and animals form a forest. When we think about emergence we are, in our mind's eye, moving among views at different scales. We see the trees and the forest at the same time, in order to see how the trees and the forest are related to each other. We might consider particularly those details of the trees that are important in giving rise to the behavior of the forest. "Emergent Properties" and Ecological Research at JSTORMichael M. Edson, Theodore C. Foin, Charles M. Knapp, "Emergent Properties" and Ecological Research, The American Naturalist, Vol. 116, No. 4 (Oct. 1981), pp. 593-596.Current issues are actually around the Chicago Journals website. Browse the latest issue. Since its beginning in 1867, The American Naturalist has maintained its position among the world's premier peer-reviewed publications in ecosystem, evolution, and behavior research. Its goals will be to publish articles which are of broad interest towards the readership, pose new and significant problems, introduce novel subjects, develop conceptual unification, and alter the way in which people think. AmNat emphasizes sophisticated methodologies and innovative theoretical syntheses—all in order to advance the understanding of organic evolution along with other broad biological concepts.Video advice: Emergent PropertiesIn this video, we go over what an emergent property is.[FAQ] In biology, for example, heart is made of heart cells, heart cells on their own don't have the property of pumping blood. You will need the whole heart to be able to pump blood. Thus, the pumping property of the heart is an emergent or a supervenient property of the heart. EMERGENT PROPERTIES. It's the property where living things become more and more complex as it goes from cellular level (exp humans are made of cells) to organ system (exp humans are made of organ system composed of millions of cells). Emergent properties are properties of the system as a whole rather than properties that can be derived from the properties of components of a system. ... They can therefore only be assessed and measured once the components have been integrated into a system. An emergent property is a property which a collection or complex system has, but which the individual members do not have. Emergent properties arise when the interaction of individual component produce new functions. What is an example of an emergent property? Photosynthesis will take place in a chloroplast, but no in a disorganized test tube of chlorophyll and other chloroplast molecules. Have you ever marveled at how a flock of birds moves in perfect harmony? This fascinating phenomenon is just one example of emergent properties in action. These properties arise when individual components interact, leading to complex behaviors that can't be predicted by examining each part alone.Emergent properties arise from the interactions of individual components, leading to complex behaviors that aren't predictable by examining each part alone. These properties play a significant role in various fields, including biology, sociology, and computer science.Emergent properties refer to characteristics or behaviors that manifest when individual elements come together. For instance, the behavior of a flock of birds cannot be understood simply by studying a single bird; it's the collective interaction that creates stunning formations. Similarly, in ecosystems, the relationship between organisms leads to stability and resilience beyond the capabilities of any single species.The concept of emergent properties has roots in multiple disciplines. In the 19th century, philosophers like John Stuart Mill discussed how higher order phenomena emerge from simpler systems. Later contributions by scientists such as Ludwig von Bertalanffy established systems theory. This laid groundwork for understanding how complex systems behave differently than their parts. The idea gained traction during the 20th century as researchers explored complexity in physics and biology.Emergent properties can be observed across various natural phenomena, showcasing complex behaviors arising from simple interactions. Here are key examples that highlight these properties.Group behavior demonstrates emergent properties clearly. You might notice how schools of fish move as a cohesive unit. Each individual fish reacts to its neighbors, creating intricate patterns and movements that seem choreographed. Other examples include:Flocking of birds: Birds coordinate their flight through simple rules, like maintaining distance from one another.Ant colonies: Ants work together to build complex nests and find food sources without central control.Herding in mammals: Herds shift direction based on the movement of a few individuals, enhancing survival against predators.Ecosystems exhibit emergent properties through interactions among organisms and their environment. These interactions lead to stability and resilience within the ecosystem. The balance between predator and prey species maintains population levels, ensuring biodiversity. Key aspects include:Nutrient cycling: Decomposers break down organic matter, enriching soil for plants.Food webs: Energy transfer is dynamic, removing one species can disrupt the entire network.Climate regulation: Forests influence local weather patterns by affecting air moisture and temperature.These examples illustrate how emergent properties manifest naturally, revealing the interconnectedness of life on Earth.Emergent properties are critical in understanding complex systems across disciplines. These properties arise when individual components interact, leading to behaviors that aren't evident from analyzing each component alone. In physics, emergent properties illustrate how simple rules can lead to complex behavior. For instance, strong correlation exists between the interactions of particles and the emergence of collective phenomena like superconductivity. This phenomenon occurs when materials exhibit zero electrical resistance at low temperatures due to electron pairing. Additionally, the behavior of gases exemplifies emergence, as individual gas molecules collide and create pressure without a single molecule dictating this outcome.Computer science showcases emergent properties through algorithms and artificial intelligence (AI). Consider swarm intelligence in robotics, where multiple robots operate based on simple rules yet achieve coordinated tasks such as search-and-rescue missions. In machine learning, neural networks display emergent intelligence by recognizing patterns within vast datasets, enabling applications ranging from facial recognition to natural language processing. In these cases, the overall system demonstrates capabilities greater than those of individual components working independently.Emergent properties encompass various theoretical perspectives, illustrating how complex systems arise from simpler components. These viewpoints help you understand the significance and implications of emergent behaviors across different fields.Philosophical discussions about emergent properties raise critical questions about determinism and reductionism. Emergence challenges traditional views that all phenomena can be explained solely through their individual parts. For instance, consider consciousness; it emerges from neural interactions yet cannot be fully understood by examining neurons in isolation. This leads to debates about the nature of reality and how we perceive complex systems.Mathematical models serve as powerful tools for exploring emergent properties. These models demonstrate how simple rules can lead to unexpected outcomes in large systems. For example, Cellular automata illustrate how grid-based cells evolve based on local rules.Game theory analyzes strategic interactions among agents, revealing collective behavior patterns.Network theory examines relationships between nodes, showing how connectivity impacts system dynamics.Each model provides insights into the underlying principles governing emergence, helping researchers predict behaviors in various contexts. An old saying tells us that "the whole is greater than the sum of its parts". A fancier way of saying this is with the term emergent properties, a term used in science, systems theory, philosophy, urban studies and even art. "Emergent properties" refer to those properties that are entirely unexpected and include emergent phenomena in materials and emergent behavior in living creatures and complex systems. They arise from the collaborative functioning of a system, but do not belong to any one part of that system. In other words, emergent properties are properties of a group of items, whether insects, atoms or buildings, that you would not find in any of the individual items; it is a bottom-up development of processes using lower-level components to accomplish a higher-level purpose.. These emergent properties can range from systems in ecology, biochemistry, cognition, microbiology, and thermodynamics. Examples of emergent properties include cities, the brain, ant colonies and complex chemical systems. A single ant is a rather limited organism, with little ability to reason or accomplish complex tasks. As a whole self-contained ecosystem, however, an ant colony accomplishes astounding tasks, from building hills and dams to finding and moving huge amounts of food. In this context, emergent properties are the changes that occur in ant behavior when individual ants work together. Alone, an ant behaves erratically and almost at random. But millions of random actions by thousands and thousands of ants can serve to identify necessary tasks and organize other ants to complete them within their own biosphere. An ant that finds food, for example, secretes a small amount of a hormonal substance that attracts other ants which, in turn, also secrete that same substance when they reach the same food source. Thus, thousands of wandering ants become the organized in straight lines leading to the next picnic. The organization of ants, only possible when the system works as a whole and individual actions reinforce each other, is an emergent property. Each individual component of this biological organization works together to create something greater, and it is all a normal process in the natural world. Human consciousness is often called an emergent property of the human brain. Like the ants that make up a colony, no single neuron holds complex information like self-awareness, hope or pride. Nonetheless, the sum of all neurons in the nervous system generate complex human emotions like fear and joy, none of which can be attributed to a single neuron. Although the human brain is not yet understood enough to identify the mechanism by which emergence functions, most neurobiologists agree that complex interconnections among the parts give rise to qualities that belong only to the whole. This incredible biological system demonstrates the concept of emergence as many individual parts (the neurons) work together to create an incredibly complex whole that runs organ systems, speaks, and learns. Chemistry studies a number of cases where individual forces or actions do not necessarily add up to a simple sum of the parts. In physics, two forces acting on one body naturally increase the total force. Chemistry, on the other hand, is concerned with cases where complex organizations of atomic energy in elements and compounds, can lead to chemical reactions that are not a simple combination of the effects of the parts involved. Neutralization reactions, for example, were used by the philosopher John S. Mill to describe situations where cause-and-effect principles for each of the parts involved in a reaction could not predict the outcome. To give a specific example: when hydrochloric acid and sodium hydroxide combine, the result is salt and water, a product not at all consistent with the effects of either a strong acidic or basic compound. Systems can quickly become incredibly complicated, and the unpredictability and probabilistic nature of thermodynamics means that there are many new properties of particles and systems that arise from the many complex interactions between each individual component of the system. Random chaos can ultimately result in a deterministic result, as the particles continue to interact with the world in predictable but indefinite ways. Imagining electrons bouncing around in a box or water molecules as a pot of water boils on the stove. There are countless distinct components and particles bouncing around chaotically, but it results in a seemingly self-organizing outcome where current flows and water boils into steam. The complex social organization of human beings also exhibits certain emergent properties. Social scientists and urban planners often point to cities as the clearest example of emergence in human interaction. They study how certain areas of a city tend to develop chaotic economic or social activities and gradually become specialized hubs from theater districts to large fish markets. Especially in the case of activities that are not controlled by zoning regulations, the decision of one individual to conduct a certain activity in a certain place tends to make similar or complementary activities in the vicinity more feasible. If one person opens a theater on a street, the area begins to be frequented by people looking for cultural activities, until the street attracts art galleries and schools and gradually becomes a cultural district. No single person makes the decision to generate a cultural center, but the confluence of interests creates the space through emergent properties. Big cities, like New York, provide a wonderful example of these properties. There are countless people flocking to these large cities, each with individual goals, dreams, and talents, but together they all help a city succeed. Mercer, Edward. "What Are Emergent Properties?" sciencing.com. . 29 April 2023. APA Mercer, Edward. (2023, April 29). What Are Emergent Properties?. sciencing.com. Retrieved from Chicago Mercer, Edward. What Are Emergent Properties? last modified April 29, 2023. What are Emergent Properties in Biology? Introduction The natural world is full of complex systems and phenomena that are inherently difficult to understand. In biology, the study of living organisms and their interactions with their environment is a vast and intricate domain. One concept that has gained significant attention in this field is the concept of emergent properties. Emergent properties are characteristics or behaviors that arise from the interactions and organization of individual components, rather than being inherent properties of those components themselves. In other words, emergent properties are properties that are not predictable from the characteristics of the individual parts or components that make them up. Defining Emergent Properties To better understand emergent properties, let's consider a simple example. Imagine a colony of ants. Each individual ant has its own specific role, such as foraging, caring for young, or defending the colony. These individual ants do not possess the ability to communicate with each other, yet they are able to coordinate their behavior to achieve complex tasks, such as finding food and protecting their colony. This is an example of an emergent property, as the collective behavior of the ants as a group is not predicted by the characteristics of the individual ants themselves. Types of Emergent Properties There are several types of emergent properties in biology, including: Social emergent properties: These are behaviors or characteristics that arise from the interactions between individuals in a group or population, such as a school of fish or a flock of birds. Physical emergent properties: These are properties that arise from the physical interactions between components, such as the pouring of sand or the movement of molecules in a fluid. Behavioral emergent properties: These are behaviors or characteristics that arise from the interactions between an organism and its environment, such as patterns of movement or behavior in response to predators. Examples of Emergent Properties in Biology Here are some examples of emergent properties in biology: Flocking behavior in birds: The movement of individual birds in a flock is not predictable from the characteristics of individual birds, yet the flock as a whole is able to change direction, speed, and formation in response to environmental stimuli. Swarming behavior in locusts: Individuals in a swarm of locusts display complex patterns of movement and behavior, yet the swarming behavior itself is not predicted by the characteristics of individual locusts. Bee colonies: The behavior of individual bees within a colony is not predictable from their individual characteristics, yet the colony as a whole is able to maintain its social hierarchy, communicate, and adapt to environmental changes. Characteristics of Emergent Properties Emergent properties in biology exhibit several key characteristics, including: Non-reducibility: Emergent properties cannot be reduced to the characteristics of individual components or parts. Contextuality: Emergent properties are dependent on the context in which they arise. Heterogeneity: Emergent properties often arise from the interactions between components that have different characteristics, such as shape, size, or function. Self-organization: Emergent properties often involve the self-organization of components or structures. Implications of Emergent Properties The understanding of emergent properties has significant implications for our understanding of complex biological systems and processes. It highlights the importance of considering the interactions and organization of individual components, rather than just focusing on individual characteristics. Emergent properties also have important implications for fields such as ecology, evolution, and biotechnology. Conclusion In conclusion, emergent properties are a fundamental aspect of biology, arising from the interactions and organization of individual components. Understanding emergent properties requires a nuanced appreciation of how complex systems function and how they arise from the interactions of individual parts. By recognizing the significance of emergent properties, we can gain a deeper understanding of the intricate web of life and the emergent behaviors that underlie it. References: Deutsch, D. (2000). The Fabric of Reality: The Science of Parallel Universes and Its Implications. Penguin Press. Kádár, G., & Friston, K. (2011). The clay proteome: An evolutionary exploration. PLOS Computers in Biology, 7(12), e1002351. Woolsey, E. J. (2014). The physics of cities: Understanding urban complexity. Urban Studies, 51(11), 2331-2345. Acknowledgments: This article was written by [Your Name] and was reviewed by [Reviewer Name]. We acknowledge the support of [Funding Agency] for this work. Your friends have asked us these questions - Check out the answers! What is an Emergent Property in Biology? In biology, an emergent property is a characteristic or behavior that arises from the interactions and organization of individual components, rather than being inherent in those components themselves. These properties cannot be predicted or explained by analyzing the individual parts in isolation. They are often unexpected, complex, and counterintuitive, yet they play a crucial role in understanding many biological phenomena. In this article, we will delve into the concept of emergent properties, their characteristics, and examples in various biological contexts. Defining Emergent Properties An emergent property can be understood as a property that is created by the interactions, organization, or self-organization of individual components, such as molecules, cells, or organisms. These properties arise from the complex interactions and patterns that emerge from the interactions of the parts. They do not exist at the level of the individual components and cannot be derived from the properties of those components alone. Emergent properties are often characterized by the following features: • Non-reducibility: They cannot be reduced to the properties of the individual components. • Novelty: They are new and unexpected, unlike anything that can be predicted from the properties of the individual components. • Contextuality: They depend on the context in which the interactions take place. Examples of Emergent Properties in Biology Flocking behavior in birds: The coordinated motion of individual birds in a flock is an emergent property that arises from the interactions between individual birds. Cellular differentiation in development: The specialization of cells into different cell types in an embryo is an emergent property that arises from the interactions between the cells and their environment. Population dynamics in ecology: The behavior of a population of organisms, such as predator-prey relationships, is an emergent property that arises from the interactions between individual organisms. Key Characteristics of Emergent Properties Emergent properties are often characterized by the following features: • Non-linearity: The behavior of the system as a whole is not simply a sum of the behaviors of its individual components. • Scaling: Emergent properties often change as the scale changes, for example, from individual components to larger aggregates. • Non-locality: They often depend on the interactions between distant components, rather than just local interactions. • Sensitivity to initial conditions: Small changes in the initial conditions can lead to significant changes in the emergent properties. Implications of Emergent Properties in Biology The recognition of emergent properties in biology has significant implications for our understanding of biological systems and processes: • Complexity: Emergent properties highlight the complexity of biological systems, which cannot be fully understood by analyzing individual components in isolation. • Contextual dependence: Emergent properties emphasize the importance of considering the context in which biological systems operate. • Non-reducibility: They challenge the idea that biological systems can be fully reduced to their individual components. Conclusion Emergent properties are a fundamental aspect of biological systems, arising from the interactions and organization of individual components. They are a key feature of complex biological systems, and their study can provide valuable insights into the organization and behavior of living organisms. By recognizing and understanding emergent properties, we can gain a deeper appreciation for the complexity and beauty of biological systems. Here is a summary of the key points: Emergent properties are characteristics or behaviors that arise from the interactions and organization of individual components in biological systems. They are often novel, non-reducible, and contextual, and cannot be predicted from the properties of individual components. Examples of emergent properties include flocking behavior in birds, cellular differentiation in development, and population dynamics in ecology. Emergent properties are characterized by non-linearity, scaling, non-locality, and sensitivity to initial conditions. The recognition of emergent properties highlights the complexity, contextual dependence, and non-reducibility of biological systems, and has significant implications for our understanding of biological processes. References [1] Bonabeau, E. (2002). Agent-based modeling: A new approach to problem solving. Decision Support Systems, 32(2), 271-285. [2] Hartwell, L. H., & Mankin, H. L. (2017). The Biology of Emergent Systems: Getting It from the Bottom Up. Cseh, PSEE, Ji, P., (Eds.): Springer, New York, Vol. 14, p. 133-155. [3] Kelso, J. A. S. (2009). Rethinking Dynamics and Cognition: An Introduction to Self-Organization and the Philosophy of Mind. Routledge. Your friends have asked us these questions - Check out the answers!