Convergence

A process in which similar characteristics evolve independently in multiple systems.

Natural or human-made systems that best approximate optimal strategies afforded by the environment tend to be successful, while systems exhibiting lesser approximations tend to become extinct. This process results in the convergence of form and function over time. The degree of convergence in an environment indicates its stability and receptivity to different kinds of innovation.

In nature, for example, the features of certain early dinosaurs—use of surface area for thermoregulation, and scales as an outer skin—evolved over millions of years to become the birds we see today. The genesis of flight for birds is different from that of other flying organisms such as bats and butterflies, but the set of adaptations for flight in all organisms has converged to just gliding and flapping. In human-created designs, this process can happen more quickly. For example, the design of virtually all automobiles today includes elements such as a four-wheel chassis, steering wheel, and an internal combustion engine—a convergence of form and function in decades versus millions of years.[1]

In both cases, the high degree of convergence indicates a stable environment—one that has not changed much over time—and designs that closely approximate the optimal strategies afforded by that environment. The result is a rate of evolution that is slow and incremental, tending toward refinements on existing convergent themes. Contrast this with the life-forms during the Cambrian period (570 million years ago) and dot-com companies of the 1990s; both periods of great diversity and experimentation of system form and function. This low degree of convergence indicates a volatile environment—one that is still changing—with few or no stable optimal strategies around which system designs can converge. The result is a rapid and disruptive rate of evolution, often resulting in new and innovative approaches that depart from previous designs.[2]

Consider the level of stability and convergence in an environment prior to design. Stable environments with convergent system designs are receptive to minor innovations and refinements but resist radical departures from established designs. Unstable environments with no convergent system designs are receptive to major innovations and experimentation, but offer little guidance as to which designs may or may not be successful. Focus on variations of convergent designs in stable environments, and explore analogies with other environments and systems for guidance when designing for new or unstable environments.[3]

See also Iteration, Mimicry, and Most Advanced Yet Acceptable.

[1] See, for example, *Cats' Paws and Catapults: Mechanical Worlds of Nature and People* by Steven Vogel, W. W. Norton & Company, 2000.

[2] For opposing perspectives on convergence in evolution, see *Wonderful Life: The Burgess Shale and the Nature of History* by Stephen Jay Gould, W. W. Norton & Company, 1990; and *The Crucible of Creation: The Burgess Shale and the Rise of Animals* by Simon Conway Morris, Oxford University Press, 1998.

[3] Alternatively, environments can be modified. For example, stable environments can be destabilized to promote innovation—e.g., a shift from managed markets to free markets.

Environmental and system analogies often reveal new design possibilities. The set of strategies for flight has converged to just gliding and flapping but expands to include buoyancy and jet propulsion when flight is reconsidered as movement through a fluid. In this case, the degree of convergence still indicates environments that have been stable for some time. New flying systems that do not use one or more of these strategies are unlikely to compete successfully in similar environments.