

# Military Revolutions, Evolution, and International Relations Theory

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## **Introduction**

Military revolutions constitute a significant challenge to international relations theorists. The combination of changes in military technology, organization, and operational concepts has collectively altered the structure and composition of international systems. These changes go beyond the classical concerns for the dynamics of the international system or the diffusion of weapons technology, which emphasize shifts in the balance of power between states, to concerns over the particular states themselves, affecting the boundaries within and between them.

Changes of the kind characterized by military revolutions have been a significant focus of military historians and others focused on the formation and dissolution of states, but explaining their occurrence remains a theoretical challenge to international relations theorists who maintain strong ontological commitments to the state as a discrete unit of analysis. As a result, international relations theorists have largely worked within conceptual frameworks that are inadequate for investigating phenomenon that contain cross-scale linkages, such as those that link tactical military innovation with alterations of the balance-of-power in the international system, or even those innovations that call the unity of the state into question.

In order to address the shortcomings of international relations theories, this paper examines how concepts and models from evolutionary theory might be applied to the study of military innovation, marking an initial attempt to identify aspects of evolutionary theory that may be suitable for application to international relations. In doing so, it explores neorealism and its compatibility with evolutionary theory. While neorealism does not represent the universe of international relations theory, it does serve as the foundation from which almost all studies depart and therefore sits at the core of the discipline.

Section 1, characterizes military revolutions as defined by various military historians, and motivates the turn towards evolutionary theory. Section 2 examines evolutionary theory, and discusses the differences between micro and macroevolution. Section 3 uses two leading neorealist texts in order to examine their approaches to the international system as a system of actors, and the forces they exert upon one another. Finally, Section 4 compares the neorealist treatment of the international system with requirements of evolutionary theory in order to find areas of agreement, disagreement, and requirements for continued theoretical development.

## **Section 1: Military Revolutions**

The concept of a military revolution was first advanced by the historian Michael Roberts in 1955, and argued that changes in military technology and tactics between 1560 and 1660 provided the basis for the formation of the modern state. Specifically, Roberts argued that the

rise of the modern European state resulted from the social, economic, technical, and organizational innovations required to “solve the perennial problem of tactics – the problem of how to combine missile weapons with close action; how to unite hitting power, mobility, and defensive strength.”<sup>1</sup>

Over the next five decades, military historians extended Roberts’ analysis, tracing the causes and consequences of military innovations by linking changes in warfare to the social, economic, and political fabric of the state itself. Over the years, military revolutions were increasingly viewed as important engines for social and political change, yet unpredictable in their timing and precise origins – owing their occurrence to a complex web of tactical, organizational, financial, and other innovations. Thus, a formalized understanding of military revolutions has eluded scholars and strategists alike who have an interest in predicting, exploiting or guarding against such disruptions to established international orders.<sup>2</sup>

In developing Roberts’ concept of a military revolution, four significant developments occurred. First, the notion of a single military revolution serving as the origin of the modern state, culminating in the Treaty of Westphalia was replaced by the idea that the modern state occurred as a result of several military revolutions, and that the innovations identified by Roberts were part of a larger chain of events occurring over an extended span of time and space.<sup>3</sup> Second, extra-European consequences of European military revolutions were identified, linking European war and politics with larger trends in world history that linked old and new worlds into a single global economic, political, and biological system.<sup>4</sup> Third, the concept of Revolutions in Military Affairs (RMAs) was developed to distinguish military innovations that affected the operational level of warfare, which required significant technical, organizational, and conceptual changes, from military revolutions and their broader strategic, political, and social consequences.<sup>5</sup> Finally, historians increasingly viewed military revolutions as discontinuities in the longer-term, but persistent evolution of warfare – qualitative jumps in the strategic character of the

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<sup>1</sup> Michael Roberts, “The Military Revolution, 1560-1660,” in Clifford J. Rogers, ed., *The Military Revolution Debate, Readings on the Transformation of Early Modern Europe* (Boulder, CO: Westview Press, 1995), pp. 13-14.

<sup>2</sup> Williamson Murray and MacGregor Knox, “Thinking About Revolutions in Warfare,” in MacGregor Knox and Williamson Murray, eds., *The Dynamics of Military Revolutions, 1300-2050* (New York, NY: Cambridge University Press, 2001), pp. 1-14; and Philip Bobbitt, *The Shield of Achilles: War, Peace, and the Course of History* (New York, NY: Anchor Books, 2002), pp. 69-74.

<sup>3</sup> For examples see Brian M. Downing, *The Military Revolution and Political Change* (Princeton, NJ: Princeton University Press, 1992); Clifford J. Rogers, ed., *The Military Revolution Debate, Readings on the Transformation of Early Modern Europe* (Boulder, CO: Westview Press, 1995); and Geoffrey Parker, *The Military Revolution: Military Innovation and the Rise of the West 1500-1800* (New York, NY: Cambridge University Press, 1996).

<sup>4</sup> William H. McNeill, *The Pursuit of Power: Technology, Armed Force, and Society Since A.D. 1000* (Chicago, IL: University of Chicago Press, 1982); John A. Lynn, *Battle: A History of Combat and Culture From Ancient Greece to Modern America* (Boulder, CO: Westview Press, 2003); J. R. McNeill and William H. McNeill, *The Human Web: A Bird’s-Eye View of World History* (New York, NY: W. W. Norton & Company, 2003); and Alfred W. Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900-1900* (New York, NY: Cambridge University Press, 2004).

<sup>5</sup> Andrew F. Krepinevich, “From Cavalry to Computer: The Pattern of Military Revolutions,” *The National Interest*, No. 37 (Fall 1994), pp. 30-43.

international system and its units that occur in addition to more gradual, incremental changes in weapons and warfare.<sup>6</sup>

In order to explain the discontinuous nature of military innovations, particularly the occurrence of those with such far reaching social consequences, the concept of punctuated equilibrium, a non-linear model of evolutionary change, was increasingly viewed as a promising conceptual lens. Its introduction allowed for an evolutionary framework to explain incremental improvements, often inconsequential at operational or strategic levels, and large-scale system level transformation that affect the very character of states from the common and persistent strategic pressures that states exert on one another. For example, Clifford Rogers noted:

In 1972, Stephen Jay Gould and Niles Eldridge proposed a new model for the evolutionary formation of species, which they dubbed "punctuated equilibrium." They argued that evolution proceeded by short bursts of rapid change interspersed with long periods of near stasis rather than constant, slow alteration... This newer conception of punctuated equilibrium evolution, combining both incremental and "revolutionary" change, seems to describe the process of military innovation extraordinarily well. After a long period of near-stasis, infantry began to evolve very rapidly around the beginning of the fourteenth century. Cannon appeared about that time, evolved incrementally for a century, then in a burst of rapid advancement revolutionized war in Europe. Artillery fortification began to develop at about the same time as artillery reached its height; evolved gradually over the course of a century; then in their turn effected a military revolution. A similar process of punctuated equilibrium in military technology continues even today.<sup>7</sup>

More recently, John Lynn argued that the linkage between military revolutions and punctuated equilibrium marked an important step in the development of a theory of military innovation and diffusion, an area of significant theoretical weakness in military history and international relations:

And the fact is that there have been precious few attempts to formulate a theory of military change, or even a narrative on the subject, on either side of the social science divide. It is interesting to note that military historians have been most likely to produce what general gambits there are ... suggesting the use of a variant of punctuated equilibrium theory advanced by evolutionary biologist Stephen J. Gould. Gould's notion that evolution is not a smooth process, but moves by a series of rapid jumps followed by periods of relative stability, has been imported into the social sciences as well. As yet this punctuated equilibrium hypothesis has yet to receive the full development it deserves, but it seems promising.<sup>8</sup>

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<sup>6</sup> Clifford J. Rogers, "'Military Revolutions' and 'Revolutions in Military Affairs': A Historian's Perspective," in Thierry Gongora and Harald von Riekhoff, eds., *Toward a Revolution in Military Affairs?: Defense and Security at the Dawn of the Twenty-First Century* (Westport, CT: Greenwood Press, 2000), pp. 21-36.

<sup>7</sup> Clifford J. Rogers, "The Military Revolutions of the Hundred Years War," in Clifford J. Rogers, ed., *The Military Revolution Debate: Readings on the Military Transformation of Early Modern Europe* (Boulder, CO: Westview Press, 1995), p. 77; also see Geoffrey Parker, "Introduction: The Western War of War," in Geoffrey Parker, ed., *The Cambridge History of Warfare* (New York, NY: Cambridge University Press, 2005), pp. 5-6.

<sup>8</sup> John A. Lynn, "Reflections on the History and Theory of Military Innovation and Diffusion," in Colin Elman and Miriam Fendius Elman, eds., *Bridges and Boundaries: Historians, Political Scientists, and the Study of International Relations* (Cambridge, MA: MIT Press, 2001), p. 374.

As will be discussed later, evolutionary theory may have important application for the study of military innovation, particularly in distinguishing between RMAs and military revolutions. RMA strategists advocated the occurrence of revolutionary dynamics, arguing that they were not evolutionary, and that they were endogenous to states, resulting from the investments and experiments that national militaries choose to avoid or exploit in emerging technologies and concepts, placing their occurrence within the bounds of rational, strategic control. By comparison, military revolutions were regarded as exogenous social and technological events whose occurrence restructured states and their armed forces, but were beyond the control of military organizations.<sup>9</sup>

These distinctions complicate the punctuated equilibrium model of military revolutions while creating new opportunities to import evolutionary theory into the study of military innovation and international relations. As the next section discusses, the endogenous vs. exogenous character of RMAs and military revolutions has parallels in evolutionary theory, distinguishing microevolution from macroevolution. Therefore, military innovations may not be characterized by a single model of evolution, but rather align with many different versions of evolutionary theory, each suggesting different dynamics and patterns of change despite all sharing their roots in the same abstract process.

## **Section 2: Evolutionary Theories of Historical Change**

Evolutionary theory, sits at the center of many different disciplines – ranging from ecological or macro scale concerns over the diversity and abundance of species, to micro level examinations of the frequency of particular genes, to more general notions of self-organization, path-dependence, and complex adaptive systems.<sup>10</sup> Theorization about evolutionary processes has been extensive and is by no means settled. Controversies exist within the domains of ecology, evolutionary development, evolutionary biology, molecular genetics, and other fields over theoretical, empirical, ontological, and epistemological grounds. Thus, while military historians and strategists have gravitated towards punctuated equilibrium, it is only one of many models of evolution that warrant consideration in the context of military innovation.

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<sup>9</sup> Williamson Murray and Allan R. Millett, eds., *Military Innovation in the Interwar Period* (New York, NY: Cambridge University Press, 1996); Williamson Murray and MacGregor Knox, “The Future Behind Us,” in MacGregor Knox and Williamson Murray, eds., *The Dynamics of Military Revolutions, 1300-2050* (New York, NY: Cambridge University Press, 2001), pp.179-188; Williamson Murray, “Innovation: Past and Future,” in Williamson Murray and Allan R. Millett, eds., *Military Innovation in the Interwar Period* (New York, NY: Cambridge University Press, 1996), pp. 306-310; Clifford J. Rogers, ““Military Revolutions” and “Revolutions in Military Affairs”: A Historian’s Perspective,” in Thierry Gongora and Harald von Riekhoff, eds., *Toward a Revolution in Military Affairs?: Defense and Security at the Dawn of the Twenty-First Century* (Westport, CT: Greenwood Press, 2000), pp. 21-36; and Michael C. Horowitz, *The Diffusion of Military Power: Causes and Consequences for International Politics* (Princeton, NJ: Princeton University Press, 2010).

<sup>10</sup> Example texts that link evolution, ecology, and complex systems together include Ernst Mayr, *What Evolution Is* (New York, NY: Basic Books, 2001); Nicholas H. Barton, Derek E.G. Briggs, Jonathan A. Eisen, David B. Goldstein, and Nipam H. Patel, *Evolution* (Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 2007); and Simon A. Levin, ed., *The Princeton Guide to Ecology* (Princeton, NJ: Princeton University Press, 2009).

## Evolution, Abstraction and Hierarchy

Evolution, as an abstract process, is well defined and based on three essential features: variation, heritability, and selection.<sup>11</sup> As long as a population is heterogeneous in dimensions upon which fitness varies, selection pressure ensures that those with greater fitness reproduce at a greater rate than those with lower fitness, and offspring inherit the traits of their parents, then Darwinian evolution can occur. While this characterization is an accurate description of the core of evolutionary processes this it is also incomplete when describing biological, ecological, and social systems.

Complex systems are hierarchical, so defining what constitutes a unit of analysis, what is heritable and how is it passed on, and how fitness is measured and tested may vary across levels of analysis and complex feedback between them may exist.<sup>12</sup> Organisms with high fitness genes may nevertheless have fewer offspring than those who are less fit in cases where group, kin or sexual selection occurs. Conversely, competition within an organism can reward cellular variations that are unhealthy for the organism as whole, as in the case of cancer tumors that arrogate resources and space for their own needs while disrupting the overall bodily functions of the organism and threatening its health.<sup>13</sup> In each case, selection at one level of aggregation can affect the fitness of others, meaning that hierarchies contain feedbacks between units and levels and causal mechanisms that link levels in both directions.

The challenge of hierarchy in evolution cannot be understated, as questions about units of selection and the aggregation lie at the heart of many contemporary debates.<sup>14</sup> For example, some biologists focus on individual genes and changes in their relative frequencies in populations; others emphasize the individual organism as the unit of analysis; still others emphasize the fate of species.<sup>15</sup> In each of these cases, the ways in which processes of variation, selection, and reproduction operate differently, giving rise to alternative dynamics by which major change occurs, or even if it occurs at all. Therefore, the model of punctuated equilibrium that has captured the attention of military historians is one of many evolutionary models that can enrich the study of military innovation.

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<sup>11</sup> Samir Okasha, *Evolution and the Levels of Selection* (New York, NY: Oxford University Press, 2006), p. 10.

<sup>12</sup> On the relationship between hierarchy and complexity, and the challenges of interdependence and feedback see Howard H. Pattee, ed., *Hierarchy Theory: The Challenge of Complex Systems* (New York, NY: George Braziller, 1973); and Herbert A. Simon, *The Sciences of the Artificial* (Cambridge, MA: MIT Press, 1996), pp. 183-216.

<sup>13</sup> Samir Okasha, *Evolution and the Levels of Selection* (New York, NY: Oxford University Press, 2006), pp. 11-12, and 40-46.

<sup>14</sup> R. V. O'Neill, D. L. DeAngelis, J. B. Waide, and T. H. Allen, *A Hierarchical Concept of Ecosystems* (Princeton, NJ: Princeton University Press, 1986); and Simon A. Levin, "The Problem of Pattern and Scale in Ecology," *Ecology*, Vol. 73, No. 6 (1992), pp. 1943-1967.

<sup>15</sup> Examples of examinations of evolution at different levels of analysis include Richard Dawkins, *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe Without Design* (New York, NY: W. W. Norton & Company, 1996); Ernst Mayr, *What Evolution Is* (New York, NY: Basic Books, 2001); Kim Sterenly, *Dawkins Vs. Gould: Survival of the Fittest* (Lanham, MD: Totem Books, 2001); and Stephen Jay Gould, *Punctuated Equilibrium* (Cambridge, MA: The Belknap Press of Harvard University Press, 2007).

## Punctuated Equilibrium and Micro vs. Macroevolution

Punctuated equilibrium advanced the view that evolution occurs at uneven rates, oscillating between stasis or movement around a phenotypic mean, and major speciation or extinction events.<sup>16</sup> While many observers outside of the disciplines of biology, ecology and paleontology interpreted this as a revolutionary claim, the actual controversy within these disciplines did not concern the rate of change as much as its process. Gould and Eldridge argued that punctuated equilibrium resulted from macroevolution, where selection pressures and fitness were determined at the level of the species not the individual organism, i.e. species selection.

I have linked my treatments of punctuated equilibrium and the hierarchical theory of natural selection... because I believe that punctuated equilibrium supplies the central argument for viewing species as effective Darwinian individuals at a relative frequency high enough to be regarded as general – thereby validating the level of species as a domain of evolutionary causality, and establishing the effectiveness and independence of macroevolution by two of the three criteria featured... as indispensable foundations of Darwinism.

*First*, punctuated equilibrium secures the hierarchical expansion of selectionist theory to the level of species, thus moving beyond Darwin's preference for restricting causality effectively to the organismic realm alone... *Second*, by defining species as the basic units or atoms of macroevolution – as stable “things” (Darwinian individuals) rather than as arbitrary segments of continua – punctuated equilibrium precludes the explanation of all evolutionary patterns by extrapolation from mechanisms operating on local populations, at human timescales, and at organismic and lower levels... Thus... punctuated equilibrium presents no radical proposal in the domain of microevolutionary mechanics – in particular (and as so often misunderstood), the theory advances no defenses for saltational models of speciation, and no claims for novel genetic processes. Moreover, punctuated equilibrium does not attempt to specify or criticize the conventional mechanisms of microevolution at all... In other words, *punctuated equilibrium makes its major contribution to evolutionary theory, not by revising microevolutionary mechanics, but by individuating species (and thereby establishing the basis for an independent theoretical domain of macroevolution)*.<sup>17</sup>

This version of evolution challenged adaptationist, microevolutionary approaches that emphasized changes within a species as the accumulation of changes in traits based on the determination of fitness and selection of individual organisms. Adaptationist reactions to punctuated equilibrium were strong and skeptical because it relied on the treatment of aggregates of individuals as a single organism that represented an entire species. Having already fought major battles over group and kin selection, microevolutionists were wary of any theory that treated anything other than the individual organisms as the unit of selection.

Whereas group and kin selection addressed questions of altruism, species selection dealt with evolutionary forces acting on properties that only groups could possess, such as genotypic diversity and spatial dispersion. Thus, in punctuated equilibrium the sudden emergence or

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<sup>16</sup> Niles Eldridge, *Macroevolutionary Dynamics: Species, Niches, & Adaptive Peaks* (New York, NY: McGraw-Hill, 1989), p. 65.

<sup>17</sup> Stephen Jay Gould, *Punctuated Equilibrium* (Cambridge, MA: The Belknap Press of Harvard University Press, 2007), p. 58.

extinction of species was the result of exogenous forces acting on populations, such as climate change or meteor strikes. In these cases, those populations that possessed the most genetic diversity and covered the largest swaths of geographic territory were most likely to survive cataclysmic events, while the fragmenting of the environment isolated survivors and allowed for their rapid speciation by disrupting gene flows.<sup>18</sup>

Punctuated equilibrium also introduced the concepts of diversity and disparity as measures of difference between species. In this context, diversity referred to the number of species in the environment, while disparity was a measure of their relative differences or similarities. Thus, a system with one hundred birds may possess diversity, but little disparity, while a system with a single lizard, ape, and elephant would have little diversity, but high disparity. By comparing the relative diversity and disparity of systems, punctuated equilibrium theorists inverted the sequence by which organisms developed features and traits. For example, microevolutionists argued that species adapted overtime, and that major transitions in the history of a species were the cumulative effects of adaptation and mutation. By comparison, the punctuated equilibrium model suggested that diversity peaked early in the history of a system and then diminished overtime as relatively unfit species slowly went extinct as a result of background extinctions.

Gould argues that evolutionary trends are not the scaled-up consequences of competitive interactions amongst organisms. One much repeated example of an evolutionary trend is the evolution of horses. Horse evolution saw a switch, the story runs, from browsing on trees and bushes to grazing on grasses. This generated correlated morphological changes. Horses became larger, with longer, higher-crowned teeth, and at the same time lost their toes as their feet turned to hooves. If it were the right view of horse evolution, the example would be a triumph of extrapolationism. The evolutionary pattern in the horse lineage would be the aggregation, the summary, of a multitude of interactions in particular populations, most of which had some upshot. But Gould reinterprets this history. It is not a result of the competitive success of grazers with those characteristics over browsing horses and less well-designed grazing horses. Rather, Gould argues that this trend is really a change in the spread of variation within the horse lineage. The horse lineage used to be species-rich with a wide range of horse lifestyles and sizes. But only a few species survived, and those few happen to be largish horses. The average horse is larger now only because almost all horse species went extinct, and the few survivors happened to be somewhat atypical.<sup>19</sup>

Species selection that operating on the collective properties of the group meant that the fittest, best adapted members of the environment might not necessarily be the survivors when exogenous shocks to the system occurred. Species survival was as much a matter of luck and contingency, and organisms were not always moving towards an adaptive optimum. This argument directly challenged the adaptationist perspective of evolution where all traits could be explained by their contribution to an organism's fitness.

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<sup>18</sup> Stephen Jay Gould, *Punctuated Equilibrium* (Cambridge, MA: The Belknap Press of Harvard University Press, 2007), pp. 81-82.

<sup>19</sup> Kim Sterelny, *Dawkins Vs. Gould: Survival of the Fittest* (Lanham, MD: Totem Books, 2001), pp. 72-73.

## Migration, Genetic Drift, and Transmission Bias

Evolutionary theory has many components and other important forces have played an important role in the life history of species. In addition to natural selection, i.e. the removal of low fitness individuals from a population each generation, migration, drift, and transmission bias exert powerful effects on organisms.<sup>20</sup> Migration refers to the physical movement of individuals or populations, and is often treated as synonymous with gene-flow, which refers to the placement of genes into new environments.<sup>21</sup>

Genetic drift suggests that populations change at random as a result of random processes.<sup>22</sup> Many of the changes that occur in gene frequencies are simply random deviations, and are neutral with respect fitness meaning that they are not subject to natural selection. Genes and traits may change over time, yet no change in fitness may result.<sup>23</sup> Likewise, because genes are transmitted via sexual reproduction some traits may be lost from the population simply due to stochastic fluctuations caused by mate-selection, particularly in small or geographically isolated populations.<sup>24</sup>

Transmission bias is commonly a result of cultural or sexual selection where social practices or preferences bias the transmission of maladaptive genes by promoting socially desirable traits.<sup>25</sup> Transmission bias suggests that social and cultural choices can overwhelm the “hill-climbing” process of natural selection by promoting traits that are maladaptive and expensive to the individual, such as ornamental markings and physiological traits that attract mates but make evasion from predators more difficult, as evident by the peacock’s tail.<sup>26</sup>

## Strategic Interaction: Frequency-Dependent Selection and Coevolution

Frequency-dependent selection and coevolution are two additional concepts that warrant attention because they link organisms and species into coherent ecological systems. In each case selection is interdependent or strategic, where the fitness of one unit is contingent on the presence or absence of others. Frequency-dependent selection operates over a closed set of

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<sup>20</sup> Samir Okasha, *Evolution and the Levels of Selection* (New York, NY: Oxford University Press, 2006), p. 28

<sup>21</sup> Nicholas H. Barton, Derek E.G. Briggs, Jonathan A. Eisen, David B. Goldstein, and Nipam H. Patel, *Evolution* (Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 2007), pp. 793-794.

<sup>22</sup> Nicholas H. Barton, Derek E.G. Briggs, Jonathan A. Eisen, David B. Goldstein, and Nipam H. Patel, *Evolution* (Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 2007), pp. 413-414.

<sup>23</sup> Ernst Mayr, *What Evolution Is* (New York, NY: Basic Books, 2001), p. 199; Peter J. Bowler, *Evolution: The History of an Idea* (Berkeley, CA: University of California Press, 2003), p. 351; and Nicholas H. Barton, Derek E.G. Briggs, Jonathan A. Eisen, David B. Goldstein, and Nipam H. Patel, *Evolution* (Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 2007), pp. 413-415;

<sup>24</sup> Ernst Mayr, *What Evolution Is* (New York, NY: Basic Books, 2001), p. 99.

<sup>25</sup> Kiyoso Takahasi, “Evolution of Transmission Bias in Cultural Inheritance,” *Journal of Theoretical Biology*, Vol. 190, No. 2 (January 1998), pp. 147-159.

<sup>26</sup> Richard Dawkins, *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe Without Design* (New York, NY: W. W. Norton & Company, 1996), pp. 283-284; and Nicholas H. Barton, Derek E.G. Briggs, Jonathan A. Eisen, David B. Goldstein, and Nipam H. Patel, *Evolution* (Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 2007), pp. 573-579; and Jerry A. Coyne, *Why Evolution is True* (New York, NY: Penguin Books, 2009), pp. 144-147.

phenotypes, e.g. the game rock-paper-scissors, in which the benefits of possessing certain traits or employing particular strategies vary based on the particular environmental context.<sup>27</sup> By comparison, coevolution characterizes how species mutually adapt to one another, often in predator-prey and host-parasite relations. As in frequency-dependent selection, fitness is contingent on others, but because species mutually adapt their interactions can give rise to new phenotypes. Coevolution constitutes a search through an open system and can result in cycles between phenotypes or even the appearance of stasis at the system level, despite persistent innovation on the part of the system's units, i.e. the red queen effect.<sup>28</sup>

Coevolution can result in three major forms of interaction: mutualism, predator-prey relations, and parasitism. Mutualism is often assumed to reflect altruism, and is commonly viewed as evidence of group or kin selection mentioned earlier. However, mutualism often reveals strong competitive pressures at other levels in a system's hierarchy, suggesting that it maintains a competitive basis at other levels in an ecological hierarchy.<sup>29</sup>

Whereas mutualism characterizes mutually beneficial relations between genes, cells, organisms, etc., predator-prey and parasitism characterize interactions that are directly harmful to at least one of the actors involved. Predator-prey relationships are most visible in the structuring of ecosystems via food webs, since each organism looking for food is potentially the prey of other organisms.<sup>30</sup> From an evolutionary perspective, predator-prey relations terminate the prey's genes unless it adapts successful abilities to evade, escape, defend, or otherwise protect itself from predation, while predators must evolve suitable responses to changes in its prey, choosing different species to prey upon.

Parasitism, by comparison, provides an alternative model of competitive interaction between organisms. Whereas predator-prey interactions are often characterized as a single battle upon which life and death are determined, host-parasite competition is an extended conflict that begins with the parasite seeking to invade the host, only to enter into an extended dynamic battle with the host's immune system. This conflict often occurs through the use of surrogates, with parasites affecting genotypes and phenotypes of hosts in order to make them suit their own

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<sup>27</sup> John Maynard Smith, *Evolution and the Theory of Games* (New York, NY: Cambridge University Press, 1982); B. Sinervo and C. M. Lively, "The Rock-Paper-Scissors Game and the Evolution of Alternative Male Strategies," *Nature*, Vol. 380 (March 21, 1996), pp. 240-243; Patrik Nosil, "Frequency-Dependent Selection: When Being Different Makes You Not Stand Out," *Current Biology*, Vol. 16, No. 18 (September 19 2006), pp. R806-R808; and Nicholas H. Barton, Derek E.G. Briggs, Jonathan A. Eisen, David B. Goldstein, and Nipam H. Patel, *Evolution* (Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 2007), pp. 470-475.

<sup>28</sup> Nicholas H. Barton, Derek E.G. Briggs, Jonathan A. Eisen, David B. Goldstein, and Nipam H. Patel, *Evolution* (Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 2007), pp. 509-510

<sup>29</sup> Simon A. Levin, *Fragile Dominion: Complexity and the Commons* (Cambridge, MA: Perseus Publishing, 1999), p. 36. Also see Geerat J. Vermeil, *Nature: An Economic History* (Princeton, NJ: Princeton University Press, 2004).

<sup>30</sup> Joel S. Brown, "Foraging Behavior," in Simon A. Levin, ed., *The Princeton Guide to Ecology* (Princeton, NJ: Princeton University Press, 2009), pp. 51-58.

biological needs, often ensuring that infected hosts become easy prey for predators to catch and kill because of the parasite's own life cycle requirements.<sup>31</sup>

Finally, coevolutionary interactions can be tight or diffuse.<sup>32</sup> Tight coevolution characterizes situations where adaptive feedback between organisms is strong and centered around the specialized relations between species. For example, many plants and pollinators have developed one-to-one correspondence with one another where a change in the traits of one species exerts direct pressure on the other to adapt.<sup>33</sup> By comparison, diffuse coevolution characterizes situations where species are adapting to one another but not in a highly coupled fashion. In such cases, predators may adapt to changes in the availability of prey, but their prey may not consist exclusively of a single species and may include several substitutable species so that even if one species of prey goes extinct, the predator may simply shift to preying on another species. The distinction between tight and diffuse coevolution is important, because it differentiates between cases where species are directly tied to one another, and those in which species may be adapted to their environments but are not directly dependent on any one of the system's units.<sup>34</sup>

Having examined evolution as an abstract and multi-level process, the model and implications of punctuated equilibrium, the additional forces of migration, drift, and transmission bias, and the outcome of strategic interaction the next section will examine international relations theory, specifically structural realism through the lens of these concepts.

### **Section 3: Neorealist International Relations Theory**

International relations contains many different theoretical perspectives. This section focuses on neorealism as an exemplar of international relations theory. Realism, from which neorealism owes its intellectual heritage, is the oldest, most established theoretical perspective on international relations and is a logical point upon which to embark any analysis of international relations theory.<sup>35</sup> Second, realism, particularly neorealism, has fallen out of favor by many in the academic and policy communities, raising questions about its relevance to the current international system.<sup>36</sup> Rather than survey the entire body of neorealist literature this section will

<sup>31</sup> Claude Combes, *The Art of Being a Parasite* (Chicago, IL: University of Chicago Press, 2005).

<sup>32</sup> Daniel H. Janzen, "When is it Coevolution?" *Evolution*, Vol. 34, No. 3 (May, 1980), pp. 611-612; and Simon A. Levin, *Fragile Dominion: Complexity and the Commons* (Cambridge, MA: Perseus Publishing, 1999), pp. 150-155.

<sup>33</sup> T. T. Wiebes, "Co-Evolution of Figs and Their Insect Pollinators," *Annual Review of Ecology and Systematics*, Vol. 10 (1979), pp. 1-12.

<sup>34</sup> Jordi Bascompte and Pedro Jordano, "The Structure of Plant-Animal Mutualistic Networks," in Mercedes Pascual and Jennifer A. Dunne, eds., *Ecological Networks: Linking Structure to Dynamics in Food Webs* (New York, NY: Oxford University Press, 2006), pp. 144.

<sup>35</sup> James E. Dougherty and Robert L. Pfaltzgraff, Jr., *Contending Theories of International Relations: A Comprehensive Survey* (New York, NY: Longman, 2001), pp. 63-103.

<sup>36</sup> John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York, NY: W. W. Norton & Company, 2001), pp. 23-27; James Mann, *Rise of the Vulcans: The History of Bush's War Cabinet* (New York, NY: Viking, 2004); Paul Starobin, "The Realists," *National Journal* (September 16, 2006), pp. 24-31; and Joshua Muravchik and Stephen M. Walt, "The Neocons Vs. The Realists," *The National Interest*, No. 97 (September/October 2008), pp. 20-36.

focus on two of its most prominent works – Kenneth Waltz’s *Theory of International Politics* and John Mearsheimer’s *The Tragedy of Great Power Politics*.

## Anarchy and Hierarchy

All Realist theories, whether classical, neorealist or neoclassical, rest upon a shared set of assumptions that serve as the foundation of international relations as a distinct discipline. Realists begin from the assumption that the international system is characterized by the condition of anarchy and that relations between states are fundamentally distinct from relations within them. Thus, two basic ordering principles exist in political systems – anarchy and hierarchy. For example, Waltz argued that the differences between ordering principles divided international politics from domestic politics.

Structural questions are questions about the arrangement of the parts of a system. The parts of domestic political systems stand in relations of super- and subordination. Some are entitled to command; others are required to obey. Domestic systems are centralized and hierarchic. The parts of international-political systems stand in relations of coordination. Formally, each is the equal of all the others. None is entitled to command; none is required to obey. International systems are decentralized and anarchic. The ordering principles of the two structures are distinctly different, indeed, contrary to each other. Domestic political structures have governmental institutions and offices as their concrete counterparts. International politics, in contrast, has been called "politics in the absence of government"... International organizations do exist, and in ever growing numbers. Supranational agents able to act effectively, however, either themselves acquire some of the attributes and capabilities of states, as did the medieval papacy in the era of Innocent III, or they soon reveal their inability to act in important ways except with the support, or at least the acquiescence, of the principal states concerned with the matters at hand. Whatever elements of authority emerge internationally are barely once removed from the capability that provides the foundation for the appearance of those elements. Authority quickly reduces to a particular expression of capability. In the absence of agents with system-wide authority, formal relations of super- and subordination fail to develop.<sup>37</sup>

This argument was repeated by Mearsheimer, who also considered anarchy to be the defining feature of the international system.

The first assumption is that the international system is anarchic, which does not mean that it is chaotic or riven by disorder. It is easy to draw that conclusion, since realism depicts a world characterized by security competition and war. By itself, however, the realist notion of anarchy has nothing to do with conflict; it is an ordering principle, which says that the system comprises independent states that have no central authority above them. Sovereignty, in other words, inheres in states because there is no higher ruling body in the international system. There is no ‘government over governments.’<sup>38</sup>

The dependence on anarchy as the opposite of hierarchy, specifically defined as the absence of authority, has important theoretical consequences. First, anarchy establishes the international

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<sup>37</sup> Kenneth N. Waltz, *Theory of International Politics* (Reading, MA: McGraw-Hill, 1979), p. 88.

<sup>38</sup> John G. Mearsheimer, *The Tragedy of Great Power Politics* (New York, NY: W. W. Norton & Company, 2001), p. 30.

system as a distinct and qualitatively different realm of political behavior separated from domestic politics. Second, anarchy enables the treatment of all states as homogeneous units, only differentiated by their relative power but not their motivations or goals.

The parts of a hierarchic system are related to one another in ways that are determined both by the functional differentiation and by the extent of their capabilities. The units of an anarchic system are functionally undifferentiated. The units of such an order are then distinguished primarily by their greater or lesser capabilities for performing similar tasks. This states formally what students of international politics have long noticed. The great powers of an era have always been marked off from others by practitioners and theorists alike. Students of national politics make such distinctions as that between parliamentary and presidential systems; government systems differ in form. Students of international politics make distinctions between international-political systems only according to the number of their great powers. The structure of a system changes with changes in the distribution of capabilities across the system's units.<sup>39</sup>

Treating states as undifferentiated units allowed for neorealists to ignore the internal properties of states, such as the culture of their population, form of governments, character of leadership, and particular history, while focusing exclusively on their relative power as characterized by their military capabilities and economic potential. Thus, Waltz argued that the distribution of power across states was most important in understanding international relations, while their particular domestic properties or history could be abstracted away.

States are differently placed by their power... Power is estimated by comparing the capabilities of a number of units. Although capabilities are attributes of units, the distribution of capabilities across units is not. The distribution of capabilities is not a unit attribute, but rather a system-wide concept...

In defining international-political structures we take states with whatever tradition, habits, objectives, desires, and forms of government they may have. We do not ask whether states are revolutionary or legitimate, authoritarian or democratic, ideological or pragmatic. We abstract from every attribute of states except their capabilities. Nor in thinking about structure do we ask about the relations of states - their feelings of friendship and hostility, their diplomatic exchanges, the alliances they form, and the extent of the contacts and exchanges among them. We ask what range of expectations arises merely from looking at the type of order that prevails among them and at the distribution of capabilities within that order. We abstract from any particular qualities of states and from all of their concrete connections. What emerges is a positional picture, a general description of the ordered overall arrangement of a society written in terms of the placement of units rather than in terms of their qualities.<sup>40</sup>

This argument was repeated by Mearsheimer who insisted that states could be treated as black-boxes whose internal properties and dynamics could be ignored when analyzing their international behavior.

Structural factors such as anarchy and the distribution of power, I argue, are what matter most for explaining international politics. The theory pays little attention to individuals or domestic

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<sup>39</sup> Kenneth N. Waltz, *Theory of International Politics* (Reading, MA: McGraw-Hill, 1979), p. 97.

<sup>40</sup> Kenneth N. Waltz, *Theory of International Politics* (Reading, MA: McGraw-Hill, 1979), pp. 98-99.

political considerations such as ideology. It tends to treat states like black boxes or billiard balls. For example, it does not matter for the theory whether Germany in 1905 was led by Bismarck, Kaiser Wilhelm, or Adolf Hitler, or whether Germany was democratic or autocratic. What matters for the theory is how much relative power Germany possessed at the time.<sup>41</sup>

Because neorealists ignore the internal differences between states in favor of focusing on their capabilities they are particularly concerned with the security dilemma, a model of strategic interaction between states that rests on their inability to determine or trust in the intentions of others. In the security dilemma, efforts by one state to improve its security, predominantly by the acquisition or improvement of its arms or alliances, necessarily threatens the security of others, triggering arms races and countering alliances.

Saying that stable states make for a stable world amounts to no more than saying that order prevails if most states are orderly. But even if every state were stable, the world of states might not be. If each state, being stable, strove only for security and had no designs on its neighbors, all states would nevertheless remain insecure; for the means of security for one states are, in their very existence, the means by which others states are threatened. One cannot infer the condition of international politics from the internal composition of states, nor can one arrive at an understanding of international politics by summing the foreign politics and the external behavior of states.<sup>42</sup>

The “security dilemma,” which is one of the most well-known concepts in the international relations literature, reflects the basic logic of offensive realism. The essence of the dilemma is that the measures a state takes to increase its own security usually decrease the security of other states. Thus, it is difficult for a state to increase its own chances of survival without threatening the survival of other states.<sup>43</sup>

## Defensive and Offensive Realism

Neorealists agree on the definition of hierarchy, persistence of anarchy, the ability to focus on the distribution of power across states rather than their internal properties and the security dilemma. From this foundation, neorealism divides into defensive and offensive variants. Defensive realists, like Waltz, argue that states seek security and balances of power form as a result.

We do not expect the strong to combine with the strong in order to increase the extent of their power over others, but rather to square off and look for allies who might help them. In anarchy, security is the highest end. Only if survival is assured can states safely seek such other goals as tranquility, profit, and power. Because power is a means and not an end, states prefer to join the weaker of two coalitions... If states wished to maximize power, they would join the stronger side, and we would see not balances forming but a world hegemony forged. This does not happen

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<sup>41</sup> John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York, NY: W. W. Norton & Company, 2001), pp. 10-11.

<sup>42</sup> Kenneth N. Waltz, *Theory of International Politics* (Reading, MA: McGraw-Hill, 1979), p. 64.

<sup>43</sup> John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York, NY: W. W. Norton & Company, 2001), pp. 35-36.

because balancing, not bandwagoning, is the behavior induced by the system. The first concern of states is not to maximize power but to maintain their positions in the system.<sup>44</sup>

By comparison, Mearsheimer argued that states pursued hegemony rather than security, and that balances formed as a result of each state seeking to undermine the hegemonic aspirations of others.

My theory of offensive realism is also a structural theory of international politics. As with defensive realism, my theory sees great powers as concerned mainly with figuring out how to survive in a world where there is no agency to protect them from each other; they quickly realize that power is the key to their survival. Offensive realism parts company with defensive realism over the question of how much power states want. For defensive realists, the international structure provides states with little incentive to seek additional increments of power; instead it pushes them to maintain the existing balance of power. Preserving power, rather than increasing it, is the main goal of states. Offensive realists, on the other hand, believe that status quo powers are rarely found in world politics, because the international system creates powerful incentives for states to look for opportunities to gain power at the expense of rivals, and to take advantage of those situations when the benefits outweigh the costs. A state's ultimate goal is to be the hegemon in the system.

... In other words, survival mandates aggressive behavior. Great powers behave aggressively not because they want to or because they possess some inner drive to dominate, but because they have to seek more power if they want to maximize their odds of survival.<sup>45</sup>

## Rationality and Innovation

The differences between offensive and defensive realism affect expected dynamics of the international system in two ways. First, defensive and offensive realists disagree about the logic employed by great powers, particularly with respect to the pursuit of relative vs. absolute gains. Second is the logic of military innovation.

On the matter of decision-making, Waltz and Mearsheimer agreed on the primacy of relative gains over absolute ones, but Waltz argued that the great powers have a special responsibility to regulate the balance of powers and can afford to act according to shared interests.

... great power gives its possessors a big state in their system and the ability to act for its sake. For them management becomes both worthwhile and possible. To show how and why managerial tasks are performed internationally is the subject of this chapter. In self-help systems, as we know, competing parties consider relative gains more important than absolute ones. Absolute gains become more important as competition lessens. Two conditions make it possible for the United States and the Soviet Union to be concerned less with scoring relative gains and more with making absolute ones. The first is the stability of the two-party balances, a stability reinforced by second-strike nuclear weapons. Where a first-strike capability is almost as difficult to imagine as to achieve, gains and losses need not be so carefully counted. The second condition is the distance

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<sup>44</sup> Kenneth N. Waltz, *Theory of International Politics* (Reading, MA: McGraw-Hill, 1979), p. 126.

<sup>45</sup> John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York, NY: W. W. Norton & Company, 2001), p. 21.

between the two at the top and the next most powerful states, a distance removes the danger of third states catching up.<sup>46</sup>

According to Waltz, rival great powers could cooperate under anarchy if they transitioned from calculation the relative gains of their actions and considered the absolute ones. For Waltz, the desire to sustain the balance of power could motivate a qualitative transformation in the decision-making logic of great powers.

Alternatively, Mearsheimer argued that states would not transition from the logic of relative gains to absolute gains in their international relations because the pursuit of hegemony was absolute.

Because one state's gain in power is another state's loss, great powers tend to have a zero-sum mentality when dealing with each other. The trick, of course, is to be the winner in this competition and to dominate the other states in the system. Thus, the claim that states maximize relative power is tantamount to arguing that states are disposed to think offensively toward other states even though their ultimate motive is simply to survive. In short, great powers have aggressive intentions.<sup>47</sup>

Rather than invest in the perpetuation of the balance of power, Mearsheimer argues that great powers should always seek to enhance their power and capitalize on power asymmetries whenever the opportunity presents itself. Thus, all states, with the exception of a hegemon, are regarded revisionist, seeking to enhance their relative position at the expense of others.

There are no status quo powers in the international system, save for the occasional hegemon that wants to maintain its dominating position over potential rivals. Great powers are rarely content with the current distribution of power; on the contrary, they face a constant incentive to change it in their favor. They almost always have revisionist intentions, and they will use force to alter the balance of power if they think it can be done at a reasonable price. At times, the costs and risks of trying to shift the balance of power are too great, forcing great powers to wait for more favorable circumstances. But the desire for more power does not go away, unless a state achieves the ultimate goal of hegemony. Since no state is likely to achieve global hegemony, however, the world is condemned to perpetual great-power competition.<sup>48</sup>

Thus, while Waltz envisions a transformation in the behavior of great powers Mearsheimer argues that no transition is possible.

Another difference between Waltz and Mearsheimer can be found in the expected pattern of military arms races and innovation. Waltz argued that competitive pressures compelled states to develop similar military forces, where imitation drove the diffusion of military technologies and practices.

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<sup>46</sup> Kenneth N. Waltz, *Theory of International Politics* (Reading, MA: McGraw-Hill, 1979), p. 195.

<sup>47</sup> John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York, NY: W. W. Norton & Company, 2001), p. 34.

<sup>48</sup> John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York, NY: W. W. Norton & Company, 2001), p. 2.

The theory depicts international politics as a competitive realm. Do states develop the characteristics that competitors are expected to display? The question poses another test for the theory. The fate of each state depends on its responses to what other states do. The possibility that conflict will be conducted by force leads to competition in the arts and the instruments of force. Competition produces a tendency toward the sameness of competitors... Contending states imitate the military innovations contrived by the country of greatest capability and ingenuity. And so the weapons of major contenders, and even their strategies, begin to look much the same all over the world. Thus, at the turn of the century Admiral Alfred von Tirpitz argued successfully for building a battleship fleet on the grounds that German could challenge Britain at sea only with a naval doctrine and weapons similar to hers...

... The expectation is not that a balance once achieved, will be maintained, but that a balance, once disrupted, will be restored in one way or another. Balances of power recurrently form. Since the theory depicts international politics as a competitive system, one predicts more specifically that states will display characteristics common to competitors: namely, that they will imitate each other and become socialized to their system.<sup>49</sup>

Alternatively, Mearsheimer argued that innovation was more likely in great power competition, resulting in heterogeneous military forces and concepts as a result of the competitive pressures states exerted on one another.

... I relate my theory to the well-known realist argument that *imitation* of the successful practices of rival great powers is an important consequence of security competition. While I acknowledge the basic point as correct, I argue that imitation tends to be defined too narrowly, focusing on copycatting defensive but not offensive behavior. Moreover, great powers also care about *innovation* which often means finding clever ways to gain power at the expense of rival states.<sup>50</sup>

According to Mearsheimer, states may be homogeneous in their behavior, but be heterogeneous with respect to the military forces they develop. Importantly, Mearsheimer's model allowed for states to be homogeneous in their goals, but heterogeneous with respect to the exploitation and adoption of military innovations and the structure of their military forces.

## Section 4: Evolution and Neorealism

Neorealism has much in common with evolutionary theory. However, the dynamics of a neorealist international system are incapable of generating the patterns of dynamic change characterized by military revolutions or punctuated equilibrium. This section examines the consistencies and inconsistencies between neorealism and evolution.

### Evolution and Neorealism as Microtheory

One of the central propositions of evolutionary theory is that the structure of systems, whether chromosomes, organisms, species, or ecosystems all developed in the absence of any central planner. While evolutionary pressures may be exerted from higher levels in a system, as in the

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<sup>49</sup> Kenneth N. Waltz, *Theory of International Politics* (Reading, MA: McGraw-Hill, 1979), pp. 127-128.

<sup>50</sup> John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York, NY: W. W. Norton & Company, 2001), p. 140.

case of macroevolution, the manifest traits of actors are bottom-up innovations. Likewise, international relations theory, by definition, confronts the identical problem regarding the emergence of structure in the absence of authority. However, rather than address the question from the perspective of biology or ecology, international relations theorists turned to economics and the development of markets in order to address the emergence of macro-level structure from micro-level interactions.

The problem is this: how to conceive of an order without an orderer and of organizational effects where formal organization is lacking. Because these are difficult questions, I shall answer them through analogy with microeconomic theory. Reasoning by analogy is helpful where one can move from one domain for which theory is well developed to one where it is not. Reasoning by analogy is permissible where different domains are structurally similar.

Classical economic theory, developed by Adam Smith and his followers, is microtheory... The term "micro" in economic theory indicates the way in which the theory is constructed rather than the scope of the matter it pertains to. Microeconomic theory describes how an order is spontaneously formed from the self-interested acts and interactions of individual units - in this case, persons and firms.<sup>51</sup>

Therefore, at the most basic of conceptual levels neorealism and evolutionary theory are both interested in the emergence of structure.

### **Hierarchy in Evolution and Neorealism**

Evolutionary theory and neorealism employ fundamentally different definitions of hierarchy, which have significant implications for the study of military revolutions. Hierarchy manifests in evolutionary systems in two distinct ways. First, hierarchy deals with concerns over levels of analysis and the aggregation of units. At different levels, the forces and spatial and temporal scales of concern change. This definition of hierarchy is consistent with neorealist theory, which treats the state as a single, aggregated, unit of domestic actors that are collectively subjected to anarchy.

By comparison, the second definition of hierarchy is problematic. Another perspective of hierarchy addresses the interrelationships between units, particularly their specialization and interdependence. Neorealism partially accepts this definition, by arguing that domestic politics is structured by the specialization and interdependence of its actors, it mistakenly argues that no such differentiation exists between states because none is subservient to any other, and that all states are functionally undifferentiated. This treatment of hierarchy is problematic because it confuses specialization and the creation and occupation of niches, with authority and power.

The immediate consequence of dismissing the potential for hierarchical structuring of the international system complicates the assessment of military power, particular alliances and coalitions between units with dissimilar capabilities, in balance-of-power politics. However, a more subtle problem is that by confusing hierarchy with authority, it allows for neorealists to

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<sup>51</sup> Kenneth N. Waltz, *Theory of International Politics* (Reading, MA: McGraw-Hill, 1979), p. 89.

persistently dismiss the internal dynamics of states as factors in their international behavior, in favor of a unidirectional view of causation where the strategic demands of anarchy shape the behavior of the states, while the internal behavior of the state cannot affect the properties of the international system. This unidirectional view of causation creates an adaptationist bias in the evolution of the international system, where all properties of states, particularly their military organizations, are the result of selection for war with other states, or the result of drift because they are irrelevant.

### Homogeneity and Heterogeneity of States

The treatment of states as homogeneous black boxes is the logical consequence of Neorealist definitions of hierarchy. This assumption constitutes one of the greatest challenges for understanding the international system as an evolutionary system and the dynamics of military innovation.

First, the neorealist characterization of the international system is problematic because the history of state formation, of which military revolutions are a major component, rests on selection based on variations in the internal or constitutional order of states and their ability to harness the military and economic potential of the population. Strict adherence to neorealism's dismissal of internal politics results in deterministic and tautological assessments of state power, exposing the limitations of third-image theories.<sup>52</sup> Indeed, these limitations were exposed by Robert Keohane in *After Hegemony*, when, starting from neorealist assumptions, he explained how international regimes could extend international cooperation beyond the zenith of hegemonic power. However, Keohane's argument required the inclusion of information as a variable – specifically the accumulation of individual histories of compliance to regime norms and transparency with respect to national decision-making, all variables that characterize the features and histories of individual states.<sup>53</sup> The cooperation that Keohane theorized was achieved by the emergence of heterogeneity at the level of the individual state, thus transitioning from a third image to a second image theory as information about the specific histories of individual states developed overtime.

Keohane's analysis revealed the limits of treating the state as a black box, ignoring the variation among states that justify any meaningful selection at the international level. Instead, by arguing that the internal properties of states do not matter, they are only the subject of random drift since

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<sup>52</sup> International relations theories are often characterized by the level at which they locate the source of conflict between states. First image theories locate the origins of warfare in individual human nature; second image theories locate the origins of war in the nature of particular states, for example national ideologies such as democracy, communism, or fascism; while third image theories locate the origins of war in the structure of the international system, i.e. anarchy. See Kenneth N. Waltz, *Man the State and War: A Theoretical Analysis* (New York, NY: Columbia University Press, 1959). For critiques of neorealism as tautological see Jack Donnelly, *Realism and International Relations* (New York, NY: Cambridge University Press, 2000), p. 194; Michael C. Horowitz, *The Diffusion of Military Power: Causes and Consequences for International Politics* (Princeton, NJ: Princeton University Press, 2010), p. 40.

<sup>53</sup> Robert O. Keohane, *After Hegemony: Cooperation and Discord in International Political Economy* (Princeton, NJ: Princeton University Press, 2005), pp. 144-145.

they should be neutral from an adaptive perspective. However, the treatment of internal differences between states as neutral from an evolutionary perspective, calls into question periodic or episodic characterizations of the development of the international system, such as transitions in constitutional orders from feudal to princely to kingly to territorial, to nation-states that correspond with military revolutions.<sup>54</sup>

### States as Homogeneous in Structure but not Behavior

Another perspective on variation provided by structural realism is normative and addresses selection on the rationality of the state rather than its level of military capabilities. In evolutionary terms, this provides greater emphasis to phenotypic traits, such as morphology, where organisms may maintain similar physical attributes but employ them differently – often achieving dramatic differences in their ability to accomplish physical tasks.<sup>55</sup> Mearsheimer argued that offensive realism, his particular version of neorealist theory characterized how states should behave and that deviations from its expectations would be punished.

It should be apparent from this discussion that offensive realism is mainly a descriptive theory. It explains how great powers have behaved in the past and how they are likely to behave in the future. But it is also a prescriptive theory. States *should* behave according to the dictates of offensive realism, because it outlines the best way to survive in a dangerous world.

One might ask, if the theory describes how great powers act, why is it necessary to stipulate how they *should* act? The imposing constraints of the system should leave great powers with little choice but to act as the theory predicts. Although there is much truth in this description of great powers as prisoners trapped in an iron cage, the fact remains that they sometimes – although not often – act in contradiction to the theory. These are the anomalous cases discussed above. As we shall see, such foolish behavior invariably has negative consequences. In short, if they want to survive, great powers should always act like good offensive realists.<sup>56</sup>

This argument was used to enforce another assumption made by Mearsheimer, which was that states were rational actors who accepted and operated within the logic of anarchy.<sup>57</sup> Ironically, Waltz employed the very same argument – that international systems selected out those who behaved against the balance-of-power logic of anarchy – to argue that individual rationality was not a necessary property of states.

A self-help system is one in which those who do not help themselves, or who do so less effectively than others, will fail to prosper, will lay themselves open to dangers, will suffer. Fear of such unwanted consequences stimulates states to behave in ways that tend toward the creation of

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<sup>54</sup> Philip Bobbitt, *The Shield of Achilles: War, Peace, and the Course of History* (New York, NY: Anchor Books, 2002).

<sup>55</sup> Duncan J. Irschick and Justin P. Henningsen, “Functional Morphology: Muscles, Elastic Mechanisms, and Animal Performance,” in Simon A. Levin, ed., *The Princeton Guide to Ecology* (Princeton, NJ: Princeton University Press, 2009), pp. 27-37.

<sup>56</sup> John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York, NY: W. W. Norton & Company, 2001), pp. 11-12.

<sup>57</sup> John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York, NY: W. W. Norton & Company, 2001), p. 31.

balances of power. Notice that the theory requires no assumptions of rationality or of constancy of will on the part of all the actors. The theory says simply that if some do relatively well, others will emulate them or fall by the wayside.<sup>58</sup>

In both cases, Waltz and Mearsheimer argued that selection shaped the behavior of states, even while insisting that all states were, or should be, homogeneous. This evolutionary form of neorealism is only possible at an initial point in time, where behavioral diversity across states may exist as they have not yet been acclimated to the threat posed by one another. Overtime, however, the dynamics of the neorealist system falls into a self-perpetuating equilibrium where homogeneous behavior results and diversity is eliminated. Thus, evolution in neorealist theory runs one direction, selecting out deviations from expected behavior but offering few mechanisms for generating variety.

### **Offensive Realism and Heterogeneous Military Capabilities**

Mearsheimer's offensive realism offers one source of diversity that differs from the defensive realism of Waltz – Mearsheimer's treatment of arms races, where states pursue innovations in order to counter the capabilities of their rivals. From this perspective, the homogeneous military capabilities identified by Waltz may develop, but only to the very limited extent that a particular weapon or strategy is its own counter with respect to deterrence, defense and offense.<sup>59</sup>

Although offensive realism allows for heterogeneous military capabilities amongst states, this variation is only sensible if it is motivated by strategic competition with other states. Specifically, because neorealism subjugates all domestic politics to the needs of survival in an anarchic system, all variations in military technology, organization, or operational concepts are considered adaptive responses to external threats. Any variation generated by internal barriers to the exploration and adoption of new technologies and techniques are self-imposed limitations that will be exploited by others, and are dangerous maladaptions that may satisfy domestic political or cultural preferences, but expose the state to higher levels risk.

This vision of diversity is hyperactive with respect to the generation and diffusion of military innovations, overestimating the extent to which military forces consume national resources and are optimized to one another. In short, it advocates an adaptationist perspective where the only explanation of military structure and capabilities is their warfighting or deterrent potential. Thus, rather than ask why innovations occur and diffuse, neorealists must explain why they do not.<sup>60</sup>

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<sup>58</sup> Kenneth N. Waltz, *Theory of International Politics* (Reading, MA: McGraw-Hill, 1979), p 118.

<sup>59</sup> The categories of deterrence, defense, and offense are approximations of three of the four purposes of military power characterized by Robert Art. See Robert J. Art, "To What Ends Military Power?" *International Security*, Vol. 4, No. 4 (Spring, 1980), pp. 3-35.

<sup>60</sup> Explaining the non-adoption, rejection, or retardation of military innovations and development is a problem for neorealist theories because they insist on the exploitation of all possible means of self defense or hegemonic pursuit. For example, while RMA supporters have noted the importance of the precision-guided munitions and missiles for the future of warfare since the end of the Cold War, these same technologies, with similar expected consequences, were identified as capable of transforming warfare as early as 1949. See Vannevar Bush, *Modern Arms and Free Men: A Discussion of the Role of Science in Preserving Democracy* (New York, NY: Simon and Schuster, 1949).

## Heterogeneity and Domestic Politics

Many of the innovations that constitute military revolutions threaten the continuation of the state from within by disrupting social, cultural, and economic balances. If states only responded to the balance of power, then no distinctions between RMAs and military revolutions would exist, as any internal organizational, social, and political cost would be worth paying if it strengthened the state's chances of survival or hegemonic prospects. No necessary distinction would exist between those innovations that improve the military capabilities of the state, i.e. RMAs, and those that shift political and social balances within society that define the state, i.e. military revolutions. In evolutionary terms, neorealism's treatment of adaptation is suitable for microevolution and RMAs, but runs up against limitations when dealing with the challenge of macroevolution, when new organisms emerge that lie beyond the phenotypic limitations that a given genotype can produce.

Distinguishing between microevolutionary sources of military innovation and macroevolutionary sources is important. The history of military innovation and diffusion as microevolutionary adaptations reveals that states do ignore or resist innovations on fiscal and organizational grounds, as well as broader political, social, cultural and moral concerns.<sup>61</sup> Such resistance motivated the French to invest in siege cannon rather than emulate the English use of the long-bow for fear of arming their large peasant population during the Hundred Years War, and Prusso-German resistance to grant full officer privileges to naval engineers during the development of their battleship fleet, almost four hundred years later, for fear that they would demand social and military equality.<sup>62</sup> In evolutionary terms, these internal barriers should be categorized as expensive maladaptations, similar to the costly peacock's tail that affects their competitive position. Yet states do not always suffer as expected for retaining and institutionalizing their local customs and internal politics into their national security institutions. What is clear is that states seem to be equally fearful of domestic upheaval, rebellion and dissolution as foreign aggression and conquest.

By contrast, macroevolutionary responses to military innovations may include the restructuring of geographic sources of power or the transfer of crucial, nonmilitary skills into military service as a response to the emergence of new weapons. For example, the development of siege cannon

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<sup>61</sup> For examples see Noel Perrin, *Giving Up the Gun: Japan's Reversion to the Sword, 1543-1879* (Boston, MA: David R. Godine Publisher, 1979); Emily O. Goldman and Leslie C. Eliason, eds., *The Diffusion of Military Technology and Ideas* (Stanford, CA: Stanford University Press, 2003); Risa A. Brooks and Elizabeth A. Stanley, eds., *Creating Military Power: The Sources of Military Effectiveness* (Stanford, CA: Stanford University Press, 2007); Dima Adamsky, *The Culture of Military Innovation: The Impact of Cultural Factors on the Revolution in Military Affairs in Russia, the US, and Israel* (Stanford, CA: Stanford University Press, 2010); and Michael C. Horowitz, *The Diffusion of Military Power: Causes and Consequences for International Politics* (Princeton, NJ: Princeton University Press, 2010).

<sup>62</sup> Clifford J. Rogers, "The Military Revolutions of the Hundred Years War," in Clifford J. Rogers, *The Military Revolution Debate: Readings on the Military Transformation of Early Modern Europe* (Boulder, CO: Westview Press, 1995), pp. 55-93; and Holger H. Herwig, "The Battlefleet Revolution, 1885-1914," in MacGregor Knox and Williamson Murray, eds., *The Dynamics of Military Revolution 1300-2050* (New York, NY: Cambridge University Press, 2001), pp. 114-131.

shifted the balance of power in Europe to northern states that possessed better minerals and metals, and artisans that could forge cannon based on their preexisting skills in making church bells.<sup>63</sup>

### **Genotypic and Phenotypic Variation**

Neorealism's treatment of the state as a black box without meaningful variation in its internal properties raises the question of genotypic and phenotypic variation. The theory suggests strongly that the state is a structure derived from evolutionary convergence, where many different constitutional arrangements give rise to identical, or similar, international behavior.<sup>64</sup> This is a potentially fruitful approach to understanding the state as an evolutionary structure but requires a conceptual commitment to link domestic and international politics, an ontological commitment that runs contrary to the neorealist claims of universality.<sup>65</sup>

The treatment of states as homogeneous, whether in their capabilities, behaviors, or both violates the first tenet of evolution as selection processes require variety upon which to operate. Both Waltz and Mearsheimer argued for a form of coevolution with respect to the adaptive pressures that states place on one another through the security dilemma, but absent the ability to open the black box of the state they cannot generate sufficient diversity between states to give the international system dynamics that mirror those of punctuated equilibrium. Waltz's defensive realism envisioned homogeneous states converging on homogeneous military capabilities, likely overestimating the stability of the international system and stasis in military capabilities and balances, while Mearsheimer likely over predicts rates of innovation and change as states should be unencumbered in their search for, and exploitation of, new military capabilities.

### **Warfare, Coevolution, and Selection Pressure**

Realists of all types, as well as historians that study military revolutions, see the state as a vehicle for collective action and security.<sup>66</sup> From this perspective, the state itself is an evolutionary adaptation that resulted from communities' pursuit of security and power, with success and failure in war serving as the mechanism by which different forms of social organization, access to resources, and geographic position were tested in combat – replicating the coevolution of mutualism that rewards cooperation at one social level by enabling more effective competitors at other social levels.

From an evolutionary perspective, war is not an unnatural event, but the engine of human collective action and the ultimate arbiter of effective and ineffective social, economic, and

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<sup>63</sup> See William H. McNeill, *The Age of Gunpowder Empires 1450-1800* (Washington, DC: American Historical Association, 1989); and Caro M. Cipolla, *Guns, Sails, and Empires: Technological Innovation and the Early Phases of European Expansion, 1400-1700* (Manhattan, KA: Sunflower University Press, 2005).

<sup>64</sup> For an example of convergent evolution in the formation of the modern European state see Charles Tilly, *Coercion, Capital, and European States, AD 990-1992* (Cambridge, MA: Blackwell, 1992).

<sup>65</sup> For a critique of the neorealist ontology see Alexander Wendt, "Anarchy is What States Make of It: The Social Construction of Power Politics," *International Organization*, Vol. 46, No. 2 (Spring, 1992), pp. 391-425.

<sup>66</sup> Thomas Hobbes, *Leviathan* (New York, NY: Barnes & Noble Books, 2004).

political organization. As Michael Howard noted, the needs of war motivated the development and transformation of the modern European state:

In early modern Europe, princes had to create state mechanisms – administrative bureaucracies, legal systems, fiscal apparatus – to extract enough taxes from their subjects to enable them to conduct wars that were made increasingly expensive by the need to pay full-time mercenary forces, to build fortifications, and to buy guns. At the same time they created a common structure for reciprocal acceptance and mutual recognition, a “Society of States” that was eventually established by the Peace of Westphalia in 1648, to be updated at Utrecht in 1713 and again at Vienna a hundred years later. The legitimacy of this structure – states defined by territorial boundaries ruled by dynastic rulers “absolute” in their jurisdiction – was challenged at the end of the eighteenth century by the concept of the “nation,” one that not only created a new criterion for legitimacy but could alone provide the numbers and motivation of a new age of mass warfare. But if these newly enlisted masses were to be motivated and militarily effective the State had to provide not only defense but welfare and education, and if they did not the “audit of war” would find them out.<sup>67</sup>

Warfare as a source of evolutionary selection is consistent with the views of Waltz and Mearsheimer, particularly with respect to the considerations of rationality discussed earlier. However, the context of neorealist warfare is fundamentally systemic or global, revolving around the activities of the great powers.

The treatment of war as a systemic feature that operates as a mechanism for selecting on the global fitness of states is problematic. The history of military revolutions suggests that wars are local phenomenon, with each participant and observer learning and adapting based on their particular experiences and vantage point. Thus, the English military innovations of dismounted infantry and long-bows, which were exported to France during the Hundred Years War, were adaptations that had resulted from their local conflicts with the Scots.<sup>68</sup>

The neorealist treatment of conflict as global and uniform means that it is problematic as a means of selection for two reasons. First, coevolution, particularly at the organismic level of analysis, which best characterizes the strategic relationships between states, is based on the local interactions between specific units applying selection pressure on one another. Wars occur between real, tangible units, not abstractions.<sup>69</sup> Second, because military organizations respond differently to threats, the local context of a military conflict is essential. The English longbow and the Swiss pike were both adaptations to the military problem posed by mounted knights, but each was a solution arrived at within specific social, political, geographic, and economic

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<sup>67</sup> Michael Howard, “Foreword,” in Phillip Bobbitt, *The Shield of Achilles: War, Peace, and the Course of History* (New York, NY: Anchor Books, 2002), p. xvii.

<sup>68</sup> Clifford J. Rogers, ““As if a New Sun Had Arisen”: England’s Fourteenth-Century RMA,” in MacGregor Knox and Williamson Murray, eds., *The Dynamics of Military Revolution 1300-2050* (New York, NY: Cambridge University Press, 2001), pp. 15-34.

<sup>69</sup> Williamson Murray and MacGregor Knox, “The Future Behind Us,” in MacGregor Knox and Williamson Murray, eds., *The Dynamics of Military Revolutions, 1300-2050* (New York, NY: Cambridge University Press, 2001), p. 181.

contexts.<sup>70</sup> Even in cases of global war, such as World War I, each competitor drew different conclusions about the lessons of war and visions of what the future of conflict would demand.<sup>71</sup>

### Reification vs. Direct Interaction in Coevolution and Selection

Neorealists' place the anarchic structure of the international system at the center of international politics and treat it as the basis upon which the international behavior of states rests. In doing so, they often attribute the strategic pressures acting on states as coming from the system itself as a result of anarchy. From neorealism's perspective, states interact with a reified international system, not directly with other states.

The reification of the international system complicates the application of evolutionary theory to the study of military revolutions because it diffuses the sources of selection and masks the specific phenotypes that exert adaptive pressures on states. Indeed, by having states compete with the system, as opposed to specific threats, the possibility of tight coevolution is eliminated leaving only diffuse coevolution as an option for strategic interaction in which state compete against the aggregate of others.

The reification of the international system misses the fact that states are not simply reactive agents that respond to pressures from the international system but their decisions to initiate wars are themselves acts of selection. Thus, states are not only units upon which selection operates via success or failure in war, but they are also the agents of selection itself, initiating wars in cases where their targets are perceived to be strategically weak or politically illegitimate.<sup>72</sup> From the perspective of microevolution, military organizations interact directly with one another rather than via a reified international system.

By comparison, the reification of the international system may be more applicable for macroevolutionary concerns where aggregates of states are treated as a single species upon which selection occurs. Indeed, if military revolutions occur as a result of exogenous forces operating on military organizations, then factors not captured by neorealist anarchy, such as changes to the global environment caused by climate change, natural disasters, disease, technological change, etc., then the reification of the international system is irrelevant since the sources of military revolutions are not encapsulated by anarchy.

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<sup>70</sup> Michael Howard, *War in European History* (New York, NY: Oxford University Press, 1979), pp. 1-19; and Geoffrey Parker, "Introduction: The Western War of War," in Geoffrey Parker, ed., *The Cambridge History of Warfare* (New York, NY: Cambridge University Press, 2005), pp. 5-6.

<sup>71</sup> For examples see Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991); and Williamson Murray and Allan R. Millett, eds., *Military Innovation in the Interwar Period* (New York, NY: Cambridge University Press, 1996).

<sup>72</sup> On the relationship between wars as the determinant of legitimate and illegitimate constitutional structures see G. John Ikenberry, *After Victory: Institutions, Strategic Restraint, and the Rebuilding of Order After Major Wars* (Princeton, NJ: Princeton University Press, 2001); and Phillip Bobbitt, *The Shield of Achilles: War, Peace, and the Course of History* (New York, NY: Anchor Books, 2002).

## **The Challenge of Darwinian Evolution in the International System**

The application of evolutionary theory to international relations via the neorealist framework is problematic for all of the reasons noted above, as well other reasons. While the previous problems are not easily solvable, it is clear that neorealist assumptions can be relaxed in order to create a more flexible framework for investigating the dynamic changes that military revolutions and RMAs present. However, other problems posed by evolutionary theory are not easily dealt with because they run up against the limitations of Darwinian evolution.

Two important problems remain, both of which are connected. First, Darwinian evolution assumes that mutations, i.e. innovations in natural systems, are random in nature and are not subject to the goals, desires, or ethics of individuals, i.e. they are not purposeful. Yet, military organizations in particular and social systems in general, do not experiment at random but attempt to anticipate the consequences of their choices and act in accordance to their goals. While innovations may not be rational in the sense that they are utility maximizing, they are not random. Second, Darwinian evolution operates by passing on genotypes from one generation to the next, but what constitutes a genotype, an offspring, or a generation with respect to states and military organizations is unclear.

At the heart of this challenge lies the fact that the advent of language means that information can be transmitted across human generations and cultures. The result is that individuals and group can exert much greater control over evolutionary process within social domains, choosing what is passed on, and what is erased from history. Thus, evolution in social systems is Lamarckian, where selection and heredity operates on highly plastic phenotypes.

## **Conclusions**

Military historians' interest in punctuated equilibrium as an explanation for military revolutions as a phenomena is highly understandable, and largely consistent with concepts of macroevolution. However, despite the apparent compatibility between these concepts, international relations theory is poorly situated to explain this phenomenon or incorporate the occurrence of military revolutions into the study of the international system. The deficiencies of neorealist theory are largely representative of international relations as a discipline, because of its treatment of states as undifferentiated black boxes. While it is possible to address many of the inconsistencies of international relations theory to make it more consistent with evolutionary theory, certain bedrock challenges remain – particularly with respect to the treatment of human agency in the processes of search and heredity, because these constitute non-Darwinian social and organizational processes.