

**MALIGNANTS IN THE BODY POLITIC:  
REDEFINING WAR THROUGH METAPHOR**

BY

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A THESIS PRESENTED TO THE FACULTY OF  
THE SCHOOL OF ADVANCED AIRPOWER STUDIES  
FOR COMPLETION OF GRADUATION REQUIREMENTS

SCHOOL OF ADVANCED AIRPOWER STUDIES

AIR UNIVERSITY

MAXWELL AIR FORCE BASE, ALABAMA

JUNE 2002

# Report Documentation Page

Form Approved  
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE <b>00 JUN 2002</b>		2. REPORT TYPE <b>N/A</b>		3. DATES COVERED <b>-</b>	
4. TITLE AND SUBTITLE <b>Malignants In The Body Politic: Redefining War Through Metaphor</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Air University Maxwell Air Force Base, Alabama</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>UU</b>	18. NUMBER OF PAGES <b>68</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

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The conclusions and opinions expressed in this document are those of the author. They do not reflect the official position of the US government, Department of Defense, the United States Air Force, or Air University.

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## **ACKNOWLEDGEMENTS**

To my advisors Major John Terino and Dr. Everett Dolman: I learned much from each of you, and this work, despite its remaining flaws, benefited greatly from your contributions. It was an unconventional project from the start. Still, you gave me enough rope to hang myself, and I have the neck scars to bear witness. I truly appreciate it.

To my family: Later.

## **ABSTRACT**

In the aftermath of September 11<sup>th</sup>, President Bush declared the dawn of a new kind of war. He has repeatedly emphasized that means and measures of success in this new war will differ greatly from wars past. Yet, if this war on terrorism is unlike any other war, then what *is* it like? From the public statements of high-ranking US officials, metaphorical answers emerge: terrorism is a metastasizing cancer, a plague, a threat from which we are not immune. This paper explores the analogies of immunity, infection, and cancer. In doing so it addresses the classic strategic questions, what is the nature of the enemy, and what is the nature of the fight? In the never-ending battle against microbes and 30-year old “war on cancer,” the enemies are microbes and malignancies—threats from without the body and threats from within. In the context of the announced “war on terrorism,” I convert these biological and medical themes for reflective contemplation and conclude that the administration might look further to the language of disease to better communicate the challenges of the war on terrorists.

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# Chapter 1

## Emerging Metaphors

*This will be a different kind of conflict against a different kind of enemy.*

—President George W. Bush  
Radio address to the nation  
15 September 2001

*International terrorism also demands that we develop new ways of comprehending seemingly familiar problems. The language of “war”—and the images, metaphors, and memories it conjures up from a previous era—does not capture all of the task ahead. . . . I suggest we view international terrorism as analogous to a terrible, lethal virus.*

—Richard N. Haass  
US State Department, Director of Policy Planning  
Speech at National Defense University  
21 September 2001

In the aftermath of the terrorist attacks of September eleventh, President Bush declared the dawn of a new kind of war, “unlike any other we have ever seen.”<sup>1</sup> A month later, the noted historian Sir Michael Howard voiced concern that US officials “made a very natural but terrible and irrevocable error” when they misused the term “war.”<sup>2</sup> Invoking “war” in the struggle against terrorism, Howard asserts, could have:

dangerous consequences. To declare that one is at war is immediately to create a war psychosis that may be totally counterproductive for the objective being sought. It arouses an immediate expectation, and demand, for spectacular military action against some easily identifiable adversary, preferably a hostile state—action leading to decisive results.<sup>3</sup>

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<sup>1</sup> George W. Bush, “Address to a Joint Session of Congress and the American People,” 20 September 2001. On-line. Last accessed, 20 June 2002. Available from <http://www.whitehouse.gov/news/releases/2001/09/20010920-8.html>.

<sup>2</sup> Michael Howard, “What’s in a Name? How to Fight Terrorism,” *Foreign Affairs* 81, no. 1 (January/February 2002): 8.

<sup>3</sup> *Ibid.*, 9.

Howard is right in that the “war” word cannot be withdrawn, and the lenses of America’s twentieth century battlefield victories could distort our vision for this new war.

Less than a day after the attacks, however, President Bush “instinctively knew that we were going to have to think differently’ about how to fight terrorists.”<sup>4</sup> He quickly set out to educate the public, to reshape the lenses through which many might view the conflict:

How will we fight and win this war? We will direct every resource at our command—every means of diplomacy, every tool of intelligence, every instrument of law enforcement, every financial influence, and every necessary weapon of war—to the disruption and to the defeat of the global terror network. This war will not be like the war against Iraq a decade ago, with a decisive liberation of territory and a swift conclusion. It will not look like the air war above Kosovo two years ago, where no ground troops were used and not a single American was lost in combat. Our response involves far more than instant retaliation and isolated strikes. Americans should not expect one battle, but a lengthy campaign, unlike any other we have ever seen.<sup>5</sup>

In this we hear no cry for immediate, decisive, military action; we hear no promise of quick victory. But the President’s message is clear: our means and methods of war must differ from recent victories because the adversary differs; we need to alter our preconceptions of war.

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<sup>4</sup> Bob Woodward and Dan Balz, “10 Days in September: Inside the War Cabinet,” *Washington Post*, 28 January 2002.

<sup>5</sup> Bush, 20 September 2001. While the President discourages comparisons to the Gulf War and the Kosovo operation, National Security Advisor Condoleezza Rice has discouraged comparisons to Pearl Harbor and Defense Secretary Rumsfeld notes how we will not see victory celebrations as in World War II. Condoleezza Rice, “Press Briefing by National Security Advisor, Dr. Condoleezza Rice,” 19 September 2001. On-line. Last accessed, 20 June 2002. Available from <http://usinfo.state.gov/topical/pol/terror/01091921.htm>. Also, Donald H. Rumsfeld, “Rumsfeld Says Anti-Terrorism Efforts are Broad-Based,” 25 September 2001. On-line. Last accessed, 20 June 2002. Available from <http://usinfo.state.gov/topical/pol/terror/01092511.htm>.

If the adversary and the war are unlike any others, however, then what *are* they like? What images and metaphors more fully “capture all of the task ahead”?<sup>6</sup> Rather than summoning images of military battles and adversaries past, the President and his most senior advisors offer disease-related metaphors: “terrorism is a cancer on the human condition,” “a plague on all civilized nations,” a threat to which “we are not immune.”<sup>7</sup>

This language of disease transcends rhetorical vilification of an adversary. It suggests, depending on the disease terms one adopts, not only the nature of the adversary but also the nature of the war and some broad-based actions with which it might be fought. The State Department’s Richard Haass put forth what is, to my knowledge, the most wide-reaching application of disease language to the current crisis:

Another way of looking at the challenge is to view international terrorism as analogous to a terrible, lethal virus. Terrorism lives as part of the environment. Sometimes dormant, sometimes virulent, it is always present in some form. Like a virus, international terrorism respects no boundaries—moving from country to country, exploiting globalized commerce and communication to spread. It can be particularly malevolent when it can find a supportive host. We therefore need to take appropriate prophylactic measures at home and abroad to prevent terrorism from multiplying and check it from infecting our societies or damaging our lives. We need, for instance, better border control regimes and improved international counterterrorism cooperation across the board. We also need to make sure that the virus does not mutate into something even more

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<sup>6</sup> Richard Haass, “The Bush Administration’s Response to Globalization,” 21 September 2001. On-line. Last accessed, 20 June 2002. Available from <http://www.state.gov/s/p/rem/5508.htm>.

<sup>7</sup> The three statements were made by Secretary Rumsfeld, Secretary of State Powell, and President Bush, respectively. Donald H. Rumsfeld, “Statement of the Secretary of Defense,” No. 491-01, 7 October 2001. On-line. Last accessed, 20 June 2002. Available from [http://www.defenselink.mil/news/Oct2001/b10072001\\_bt491-01.html](http://www.defenselink.mil/news/Oct2001/b10072001_bt491-01.html); and Colin L. Powell, “Interview by Noah Adams of National Public Radio on ‘All Things Considered,’” 27 September 2001. On-line. Last accessed, 20 June 2002. Available from <http://www.state.gov/secretary/rm/2001/5091.htm>; and Bush, 20 September 2001.

deadly through the acquisition of nuclear, biological, or chemical weapons of mass destruction.

The challenge of terrorism is thus akin to fighting a virus in that we can accomplish a great deal but not eradicate the problem. We can take steps to prevent it, protect ourselves from it, and, when an outbreak occurs, quarantine it, minimize the damage it inflicts, and attack it with all our power. Therefore, the ultimate goal of our campaign is progress through the steady accumulation of individual successes. Patience and persistence will be the watchwords for this campaign.<sup>8</sup>

By borrowing the language and concepts of medicine, Haass recast the conceptual framework of the war on terrorism into something very different from traditional American wars—his is a war without a clear-defined victory ahead.

Others also invoke medical and biological metaphors to explain the task ahead. National Security Advisor Condoleezza Rice, for instance, stressed protective measures as she announced, “the United States is actively helping countries to improve their immune systems against terrorism.”<sup>9</sup> She likened eradication of deadly terrorist cells to surgical intervention: “it’s like cutting out a cancer now in 60-plus countries.”<sup>10</sup> Deputy Secretary of Defense Wolfowitz might agree. While he has spoken of a “plague of terrorists” and of the need to “drain the entire swamp,” he also sees malignancy in the evil of terrorism. “Terrorists and their evil influence have spread throughout the world like a cancer. Our response

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<sup>8</sup> Richard Haass, “The Bush Administration's Response to September 11th - and Beyond,” 15 October 2001. On-line. Last accessed, 20 June 2002. Available from <http://www.state.gov/s/p/rem/5505.htm>.

<sup>9</sup> Condoleezza Rice, “Remarks by the National Security Advisor Condoleezza Rice to the Conservative Political Action Conference,” 1 February 2002. On-line. Last accessed, 20 June 2002. Available from <http://www.whitehouse.gov/news/releases/2002/02/20020201-6.html>.

<sup>10</sup> Condoleezza Rice, “Press Briefing by National Security Advisor Condoleezza Rice, on the APEC Meeting,” 15 October 2001. On-line. Last accessed, 20 June 2002. Available from <http://www.whitehouse.gov/news/releases/2001/10/20011015-6.html>.

must be correspondingly broad, sustained, and unrelenting, ”<sup>11</sup> Wolfowitz insists, and it’s “sort of like a cancer that’s spread throughout the body. I don’t know the right analogy, but you don’t just clean it up in one place.”<sup>12</sup>

This paper explores the analogies of immunity, infection, and cancer. In doing so it addresses the classic strategic questions, what is the nature of the enemy, and what is the nature of the fight? In the never-ending battle against microbes and 30-year old “war on cancer,” the enemies are microbes and malignancies—threats from without the body and threats from within. In the context of the announced “war on terrorism,” I convert the biological and medical themes for reflective contemplation. What I do not do is advance the correct or sole analogy for our quest to rid the body politic of the terrorist blight. I do not claim that the solution to the war on terrorism provides a perfected or simple parallel to solutions found in the battle against cancer. I offer no diagnosis, no prognosis, no prescription. This is a search for questions, nothing more. Such a search is the foundation of further analysis, a preliminary evaluation of the terrorist disease that threatens us all, and the framework for what may be a fruitful means to a solution.

## **Overview**

Immunology, infectious disease, and cancer biology are enormously vast and complex fields.<sup>13</sup> The following chapters thus focus only on some major themes within these disciplines. Moreover, I have

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<sup>11</sup> Paul Wolfowitz, “Deputy Secretary Wolfowitz Interview with Indonesian Television,” 28 November 2001. On-line. Last accessed, 20 June 2002. Available from [http://www.defenselink.mil/news/Dec2001/t12012001\\_t1128wol.html](http://www.defenselink.mil/news/Dec2001/t12012001_t1128wol.html); and Paul Wolfowitz, “Remarks as Delivered by Deputy Secretary of Defense Paul Wolfowitz to the American Jewish Congress,” 22 October 2001. On-line. Last accessed, 20 June 2002. Available from <http://www.defenselink.mil/speeches/2001/s20011022-depsecdef.html>.

<sup>12</sup> Paul Wolfowitz, “Deputy Secretary Wolfowitz Interview with Atlanta Journal-Constitution,” 14 January 2002. On-line. Last accessed, 20 June 2002. Available from [http://www.defenselink.mil/news/Jan2002/t01212002\\_t0114cox.html](http://www.defenselink.mil/news/Jan2002/t01212002_t0114cox.html).

<sup>13</sup> The National Library of Medicine’s PubMed database, for instance, contains over 1.1 million cancer-related professional articles.

written the material to accommodate readers who have little familiarity with the life sciences. In this line, I do not follow standard scientific citation practices: for specialized topic coverage, I refer the reader to general reviews or news articles rather than to the original publications. Additionally, the bibliography includes a list of more accessible sources that the reader may find particularly informative.

Chapter Two concentrates on the immune system as a model protection system. I outline the general principles underpinning its successes and its failures. In so doing I introduce aspects of the microbial threat and explore a few major prevention and intervention themes in the battle against infectious disease.

Chapter Three explores the nature of the adversary and the nature of the individual battles in the war on cancer.

Chapter Four considers how we might approach the war on terror in the light of disease-related themes.

### **Some Notes on Methodology**

This is a work of metaphor. You will find no mention of terrorism—save in the epigraphs—until the concluding chapter. The intervening chapters are, on the surface, works about biology and medicine. If you read them literally, you will get a science lesson. Nothing more. To proceed beyond the science you must accept, or at least not reject, my assumption that conflict and competition in one area of life—particularly when it involves life and death—*might* reveal strategic concepts relevant to war.

I have assumed—strictly for purposes of generating ideas—that terrorists *are* infectious agents (chapter 2), or that they *are* cancer cells (chapter 3). I view the battle against disease/terror as having a threefold strategic framework: immune system as protection, public health programs as prevention, and medicine as intervention. Within this construct a discussion regarding the nature of cancer cells is also a

discussion about the *possible* nature of terrorist cells. A passage about the body's immune system warding off microbial invaders is also a passage about how a state's protective systems *might* ward off terrorist invaders. Talk about medical measures to combat malignancies is also talk about a state's (or the global community's) *potential* intervention strategies against domestic (or international) terrorism.

I will consider the work successful if it achieves any of the following goals: 1) Provides useful images—along the lines of those already used by Rice, Wolfowitz, and Haass—to help enrich understanding about the war on terror; 2) Induces others to look at seemingly familiar problems and presumed solutions from a slightly different angle; or 3) Discovers specific terms with transfer value to the war on terror.<sup>14</sup> The analogies herein breakdown, as do all others. I do not, therefore, ask that you accept a framework by analogy for the entire war on terror.<sup>15</sup> I simply ask that the reader consider whether any of the larger concepts resonate and inform.

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<sup>14</sup> The images and terms will only transfer if readily understood; I thus use language suitable for those without a scientific background. Examples of medical terms previously adopted for military use include “surgical” air strikes, the naval “quarantine” of the Cuban Missile Crisis, and the generally pejorative “antiseptic warfare.”

<sup>15</sup> Even if some of the images resonate, I ask that the reader avoid any “because cancer cells, thus terrorist cells” type of conclusions. If the nature of terrorists, for instance, seems to share much with the nature of cancer cells, then perhaps the methods for fighting the former can benefit from general principles used in fighting the latter. The images simply suggest areas for more detailed study.

## Chapter 2

### Threats from Without

*September 11th, 2001 . . . set another dividing line in our lives and in the life of our nation. An illusion of immunity was shattered.*

—President George W. Bush  
Speech at The Citadel  
11 December 2001

Immunity does not prevent attack; it protects one when attacked. But protection is conditional. The mind falls captive to the illusion of immunity when it believes that demonstrated protection against some guarantees protection against all. Writings from as early as the fifth century BCE inform us of these principles, at least in rudimentary form. When a devastating plague descended upon Athens in the second year of war with its Spartan foes, Thucydides recounts of the survivors that:

These knew what it was from experience, and had now no fear for themselves; for the same man was never attacked twice—never at least fatally. And such persons not only received the congratulations of others, but themselves also, in the elation of the moment, half entertained the vain hope that they were for the future safe from any disease whatsoever.<sup>1</sup>

While the Athenian public could trust its vaunted wall to protect it from Spartan invaders, the body must rely on “two lines of strategic defence against foreign invaders.”<sup>2</sup> Whether bacteria, viruses, or parasites, invaders first confront the body’s innate immune system—the ever ready, first responders to any attack. If innate immunity proves

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<sup>1</sup> The term “plague” in this context has no relation to bubonic plague, the Black Death of medieval Europe. Medical experts disagree as to what disease afflicted the Athenians. Excerpt from Thucydides, “History of the Peloponnesian War,” in *The Landmark Thucydides: A Comprehensive Guide to the Peloponnesian War*, ed. Robert B. Strassler (New York: The Free Press, 1996), 2.51.6.

<sup>2</sup> Kathryn Calame, “End Game for B Cells,” *Nature*, 19 July 2001, 289.

insufficient, then adaptive immunity engages. Adaptive immune responses, for instance, countered Athens' plague and endowed survivors with what we now call "protective immunity": the resistance to a specific infection after having once survived and remembered an earlier attack by the same infectious agent. But this protection demands a price: "Raising an immune response can cost the host significantly because, to some extent, a degree of collateral damage to the host's own cells and tissues is an inevitable side effect and outcome of immunity."<sup>3</sup> Therein lies the central challenge on the path to protective immunity: to distinguish self from nonself—host from invader—to limit damage to the former and eradicate the latter.

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<sup>3</sup> Rolf M. Zinkernagel and Hans Hengartner, "Regulation of the Immune Response by Antigen," *Science*, 13 July 2001, 251.

## Innate Immunity

*As porous as U.S. physical borders are in an age of burgeoning trade and travel, its “cyber borders” are even more porous—and the critical infrastructure upon which so much of the U.S. economy depends can now be targeted by non-state and state actors alike. America’s present global predominance does not render it immune from these dangers.*

—Report of U.S. Commission on National Security/21<sup>st</sup> Century

*We need to give our nation's first responders—the firefighters, the police, the medical professionals and other emergency officials—the tools to do their jobs even better. Before September 11, many in our country never thought of these men and women as first responders. Nobody really ever thought of these individuals as the first line of a homeland defense. Now today, after September 11, I believe every American understands their mission.*

—Homeland Security Director Tom Ridge  
Homeland Security and Defense Conference  
27 November 2001

Our contact with the world exposes us to danger. The ways in which we derive sustenance are those our adversaries exploit. We touch, breathe, eat, drink, procreate—each necessary port of entry a possible path of infection. Thus, the body must protect itself so that it may prosper. These unseen and often unrecognized protective efforts start with the body’s “first line of defence against infectious disease,” the innate immune response.<sup>4</sup> “Present and ready to resist an invader at any time,” generally within minutes, the innate system can control or eradicate many infections before the more slowly developing adaptive response mobilizes.<sup>5</sup> Still, some microbes may overwhelm the initial

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<sup>4</sup> Alan Aderem and Richard J. Ulevitch, “Toll-like Receptors in the Induction of the Innate Immune Response,” *Nature*, 17 August 2000, 782.

<sup>5</sup> Charles A. Janeway et al., *Immunobiology: The Immune System in Health and Disease*, 5<sup>th</sup> ed. (New York: Garland Publishing, 2001), 43. This text, written for graduate and medical students, is available on-line at the National Center for Biotechnology Information website: <http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=Books>. I also draw heavily from the very readable, undergraduate-level introduction to immunology presented in: Abul K. Abbas and Andrew H. Lichtman, *Basic Immunology: Functions and Disorders of the Immune System* (New York: W. B. Saunders, 2001).

response. The innate system, nevertheless, proves vital for an effective immune response even in such circumstances, for components of innate immunity first signal the more powerful adaptive system as to the nature of the threat and then assist it in the necessary response.

The innate “line of defense” consists of both passive and active defenses: 1) a set of barriers and 2) immune cells that recognize and respond to the threat should the barriers be breached. The body’s borders, for instance, form formidable barriers to potential pathogens, microorganisms that can cause disease. The skin is a physical barrier through which few pathogens can penetrate. The mucosal linings of the respiratory and gastrointestinal tracts form a similar yet more penetrable barrier. Other “surface defenses” include nasal hair and mucous to trap particles and cough and sneeze reflexes to expel them.<sup>6</sup> Chemical barriers complement the physical. Stomach acid kills most microbes. Sweat and oil glands, tear ducts, and the mucosal lining release antimicrobial chemicals, or peptides. Similar to antibiotics yet differing in chemical action, “The peptides are less subtle killers: They punch holes in an invader’s membranes or disrupt its internal signaling.”<sup>7</sup> Such compounds, reactive against a broad range of microorganisms, not only spare the host, they may even boost its subsequent immune response. Finally, the hundreds of species of normally harmless bacteria that inhabit the skin, mouth, and colon suppress growth of invading microbes.<sup>8</sup>

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<sup>6</sup> Arthur J. Vander, James H. Sherman, and Dorothy S. Luciano, *Human Physiology: The Mechanisms of Body Function*, 6<sup>th</sup> ed. (New York: McGraw Hill, 1994), 703.

<sup>7</sup> Trisha Gura, “Innate Immunity: Ancient System Gets New Respect,” *Science*, 16 March 2001, 2068.

<sup>8</sup> The human body contains more normal microbial flora, both on and in it, than the body has cells of its own ( $10^{14}$  bacteria as compared to  $10^{13}$  cells). These organisms may cause disease—dental caries, abdominal infections after an internal injury—but they are often harmless. Some may even provide the body a source of vitamin K and other essential nutrients. Most notably, they suppress potential pathogens by competing successfully for space and nutrients and by secreting harmful antimicrobials and waste products. Charles Patrick Davis, “Normal Flora,” in *Medical Microbiology*, 4<sup>th</sup>

Microbes do breach these barriers (through wounds, for instance), but the cells of innate immunity cannot react unless they first recognize that a breach has occurred. Recognition in the cellular community occurs through cell surface receptors that bind particles on other cell or microbe surfaces—a lock-and-key type of fit. Chemical features on microbial surfaces form the key; innate cell surface receptors the lock. Because the innate system's receptors recognize shared structures peculiar to broad classes of microorganisms, the receptors are called "pattern-recognition receptors." The recognized patterns, estimated to be less than one thousand, are often those essential for microbe survival and infectivity. The innate cells, for example, might recognize the chemical components of a bacterium's cell wall, without which the bacterium could not live any more than a human can live without skin and skeleton.

This pattern recognition approach produces three notable benefits. First, it ensures that the innate response only targets invading microbes instead of host cells, since the latter do not possess the recognized patterns. Second, it facilitates a rapid, consistent immune response. Since all innate immunity cells of a given type express the same set of receptors, many immune cells can recognize and then respond to the same microbe type. Additionally, because these receptors recognize patterns shared by broad classes of microorganisms, each immune cell can also respond to many microbe types. The net effect is that of many responders rapidly countering many types of threats. Finally, because pattern recognition often focuses on *vital* microbe components, the microbes are less able to evade immune detection—mutational changes or concealment of the target "key" might render the microbe unable to infiltrate and infect. The would-be attacker might have to alter its form and methods so much that it loses any significant power of attack.

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ed., edited by Samuel Baron (Galveston, TX: University of Texas Medical Branch, 1996), 113-19.

After the prerequisite recognition, the real strength of the innate system rests in its ability to coordinate a complex, immediate, and concerted immune response. Macrophages mediate this “cellular defense of the borders.”<sup>9</sup> Upon recognizing pathogens, the macrophages issue a flood of chemicals, the messages by which cells communicate. This chemical communication cascade initiates the familiar inflammation response—heat, redness, swelling, pain—by inducing changes in local blood vessels, part of the body’s vast transportation network. As your blood vessels expand and increase their permeability, you may experience heat, redness, and swelling. Other chemical signals released by macrophages summon assistance to the infected area. Reinforcement cells move in, taking advantage of the increased mobility allowed by the blood vessel changes. The influx of these immune cells and their resultant action cause the pain of inflammation—part of the inevitable collateral damage of effective immune responses. While the reinforcements rush in, other signals coordinate the clotting of small blood vessels downstream from the infection; these vascular roadblocks help contain and block the spread of the pathogen. Still other signals put reinforcements, the aptly named “complement proteins,” on alert in the bloodstream, a hedge should the containment strategy fail.<sup>10</sup> Finally, further chemical communications initiate wound healing to close the port of entry to further pathogens.

Innate immunity at its most effective may thwart attacking pathogens so rapidly that noticeable or disagreeable symptoms do not

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<sup>9</sup> Janeway, et al., 87. Macrophage means “large eater.” As the name indicates, these amoeba-like cells capture and ingest microbial prey, a process aptly named phagocytosis, or “cell eating.” They are also the body’s scavengers, cleaning up debris from dead or damaged cells.

<sup>10</sup> Complement proteins are not restricted to the bloodstream; they may also operate in the infected tissue. This limited example does not do justice to the role and importance of complement proteins in immunity, but the mechanisms by which they act are complex and beyond the scope of this discussion. The important point is that the immune system has several different types of first responders.

appear.<sup>11</sup> The combination of persistent border barriers; consistent and reliable recognition of known microbial patterns, or profiles; numerous, dispersed defenders with on-call reinforcements; and extensively coordinated response is formidable. Yet, pathogens arise that can breach the body's border. Others appear that do not resemble the predetermined patterns and thus evade recognition. Still more may be too powerful in either number or action for the innate system to contain. Therefore, while macrophages orchestrate the innate response, other innate immunity cells in the infected area also detect a threat, and they alert the adaptive immune system that a more potent defense might prove necessary.<sup>12</sup>

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<sup>11</sup> Scientists do not know how often this actually occurs because it is difficult to devise measures to assess the effectiveness of the innate system. If no symptoms appear, for instance, is it because a microbe never attacked or because the innate system cleared it so quickly as to negate any appearance of attack?

<sup>12</sup> Our more "advanced" system is not the universal protective model. Many multicellular organisms fare quite well with more primitive protective systems. Insects, as only one example, lack an adaptive system yet are very resistant to microbial infection. See Gura for overview.

## **Adaptive Immunity**

*A great writer has said that the struggle of humanity against tyranny is the struggle of memory against forgetting. . . . This republic is young, but its memory is long. Now, we have inscribed a new memory alongside those others.*

—President George W. Bush  
Speech at The World Will Always Remember  
September 11<sup>th</sup> Ceremony  
11 December 2001

In experiencing a pathogenic species for the first time, the adaptive immune system progresses through five general phases: recognizing the pathogen, activating armed effector cells, eliminating the pathogen, scaling back the response, and remembering the encounter.<sup>13</sup> Mobilizing this response takes time, perhaps four to seven days, and the pathogen may cause much illness during that delay. Immune memory is irrelevant to that first encounter; it may prove vital for the next. To understand why this is so, one must follow the phases of that first encounter, one initiated by innate immunity.

Recognition forms the first step on the path to memory and protective immunity. Yet, how can the immune system recognize an invader before forming a memory of that invader? The innate system, as discussed earlier, recognizes microbe patterns. While this can be thought of as a form of institutional memory, it is not memory from direct experience; the innate system of a given individual does not recall that it earlier fought the same pathogen that infects it now. Rather, the human genome encodes the lessons of countless years of evolutionary host-microbe interaction and passes these lessons down from generation to generation. The rapid pace of microbial evolution and adaptation may, however, quickly make some of these lessons obsolete as microbes don

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<sup>13</sup> I borrowed this five-phase construct borrowed from Abbas and Lichtman, 8–9. The “armed cells” reference comes from Janeway et al., which uses it frequently in discussions of adaptive immunity.

biological disguise. There is no time in such cases for the plodding advancement of human generational change and long-term adaptation. The body infected must adapt—and quickly. It does so through the adaptive system, which does not inherit a genetic file of known pathogen profiles. Instead, it creates its own profiles. Afresh. In every individual.

Since the body does not know what threats it *will* encounter, it prepares with an adaptive immune system that, ideally, can recognize and respond to any threat that it *may* encounter. To this end, the adaptive system randomly generates myriad recognition receptors before the immune system ever encounters pathogens. Each body produces perhaps a billion or more receptor types, and individual T cells and B cells each possess one type of receptor; they demonstrate specificity.<sup>14</sup> The process is somewhat akin to building billions of locks so that any yet unseen key of certain size parameters will work in at least a couple of them. The keys in this case are small biological pieces, called antigen, which *might* belong to a *possible* pathogen that the body *may* encounter. Yet, few cells exist to recognize each antigen; only one in 100,000 to one in 1,000,000 are specific for a given antigen.<sup>15</sup> The scarcity of these adaptive cells precludes dispersal for border defense, hoping for a chance contact between an antigen and the few T cells and B cells activated by recognition of that antigen. The antigen must, in effect, go to the T cells and B cells for the first encounter.

The body solves this dilemma by channeling antigen into what amounts to immune system checkpoints. Lymphatic fluid that normally drains the body's tissues sweeps antigen into the lymph nodes; the

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<sup>14</sup> T cells and B cells, also called lymphocytes, are types of white blood cells belonging to the adaptive immune system.

<sup>15</sup> This differs markedly from the innate system in which all cells of a given type could recognize the same patterns. Essentially, the innate system produces relatively few yet proven capabilities in high quantity. The adaptive, in contrast, produces near countless untried capabilities yet each in low quantity.

spleen collects antigen from the bloodstream.<sup>16</sup> Additionally, specialized antigen-presenting cells (APCs) of the innate immune system also carry antigen to these organs. APCs live in the tissues alongside macrophages; both ingest invading pathogens.<sup>17</sup> The macrophages ingest to destroy, but APCs ingest to present. The APC first degrades pathogen into DNA fragments and other antigenic pieces. It then prominently displays these pathogen antigens on its own cell surface and migrates to the nearest lymph node.<sup>18</sup> As lymphatic fluid deposits free-floating antigen and antigen-presenting cells arrive with attached antigen, the lymph node becomes an area of heavy antigen concentration. In the meantime, naïve T cells and B cells, those that have never yet encountered their matching antigen, circulate through the body's many lymph nodes. If a naïve T cell receptor does not encounter an APC that displays a matching antigen, then the T cell moves on to a different lymph node. If a B cell receptor—an antibody—does not encounter free-floating antigen, then it too moves on. In this fashion T cells and B cells, although few in number for a given antigen, can effectively survey the entire body.

Should a naïve T cell or B cell recognize antigen—that is, identify a threat—then that cell becomes activated and rapidly proliferates and differentiates into cells capable of eliminating that specific invader. This transformation from single surveillance cell to numerous armed effector cells requires, however, a second signal—chemical confirmation that the antigen is of microbial origin and not a closely matching piece of the body's own molecular makeup. Antigen-presenting cells provide this second, or co-stimulatory, signal to T cells. A certain class of these

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<sup>16</sup> The lymphatic system is more extensive than indicated here. The mucosal tissues, for instance, have specialized areas that collect antigen. I confine subsequent discussion, however, to the processes involving the lymph nodes, which are representative of those occurring in other lymphatic tissues.

<sup>17</sup> The APCs to which I refer are called dendritic cells. Although they are the most important APCs for the described processes, some other cells, including macrophages, can function as APCs in certain circumstances.

<sup>18</sup> This is how, as referred to earlier, the innate system signals the adaptive that it requires help.

activated T cells then, in a process called “linked recognition,” provides a co-stimulatory signal to B cells that have recognized antigen.<sup>19</sup> Activated T cells and B cells then remain in the lymph node and divide repeatedly for days.<sup>20</sup> Now, rather than only having one or several cells capable of binding a given antigen, the body has millions, perhaps billions, of clones all capable of recognizing the invading pathogen.<sup>21</sup> Four or five days into the rapid proliferation cycle, the T cell and B cell clones differentiate into armed effector cells—killer T cells, helper T cells, and antibody-secreting B cells.

From the development of naïve cells through the rapid expansion to armed effectors, the adaptive system must overcome a serious challenge as it prepares for emerging threats: not all antigen represent a threat. In addition to antigen from pathogens, the immune cells will also encounter antigen from self—countless pieces of the body’s own population of cells. Since the randomly generated T cell and B cell receptors exist in such large numbers, it is not surprising that many nascent cell receptors match small biological pieces native to the body. The potential thus exists for the adaptive system to mistake host cells for pathogens and unleash its killing power on the very body that it otherwise protects. The requirement for a co-stimulatory signal is just one safeguard against this self-destruction, or autoimmunity. Other extraordinarily complex control mechanisms also exist to eliminate or suppress those immune cells that do react against self. Many immature T cells and B cells that react against self will die. Others, in the case of some B cells, will undergo receptor editing: a form of reprogramming

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<sup>19</sup> In some cases, microbial components can themselves provide the second signal, and the B cell will not require assistance from helper T cells. In either case, however, the goal is the same: two signals to confirm that the T cells and B cells are reacting to a legitimate microbial threat.

<sup>20</sup> Many people have seen the effects of this proliferation in the form of “swollen glands.”

<sup>21</sup> Each pathogen likely has several antigens that the body recognizes. Thus, several different T cells and B cells, each with unique antigen receptors, may simultaneously have recognized the pathogen and then proliferated. The different receptors will then recognize different “aim points” on each microbe target.

that eliminates self-reactivity. Still others, upon maturation, will bind to self and learn not to react, a phenomenon known as “immunologic tolerance.”<sup>22</sup> Should the body’s immune system utterly fail to tightly regulate itself and develop this tolerance to its own cells, then microbes would be of slight concern—the body would destroy itself.

The immune system generally keeps its potential self-destructive power in check and turns its newly generated effector cells against invading pathogens. While the new effector cells recognize the same pathogen, they perform different eradication roles. Antibody-secreting B cells remain in the lymph nodes and secrete large quantities of antibodies into the blood. During the immune response, these “antibody molecules” are altered so they can bind to intruders more strongly.<sup>23</sup> The “intruders” are microbes that live outside of cells, either in the blood or in the tissue spaces between cells. The antibodies optimize their ability to bind and recognize, but they do not kill. Rather, they mark pathogens for destruction by others. In doing so, they also prevent immediate damage by neutralizing bacterial toxins, blocking bacteria from adhering to cells, and preventing viruses from entering cells. Moreover, antibody-marked pathogens are increasingly vulnerable to macrophage ingestion.<sup>24</sup> The macrophages, in turn, are activated by helper T cells to increase the former’s killing power. In such cases, neither antibodies nor macrophages nor helper T cells alone can eliminate the infection; it takes the concerted efforts of all to do so.

Immune cells are not the only cooperators in the protective effort; the protected also coordinate with the protectors. This is strikingly

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<sup>22</sup> The lack of a co-stimulatory signal in the presence of self-antigen can cause functional inactivation of mature T cells—the “immunologic tolerance.” This may also explain why the body normally does not react against antigens in food.

<sup>23</sup> Alberto Martin and Matthew D. Scharff, “Antibody Alterations,” *Nature*, 30 August 2001, 870.

<sup>24</sup> Some pathogens possess specialized features that allow the pathogens to conceal themselves or otherwise escape earlier destruction by macrophages of the innate system. The macrophages can, however, identify antibody-pathogen complexes and eliminate them accordingly.

revealed in the cooperation between killer T cells and their targets—pathogen-infiltrated body cells.<sup>25</sup> Killer T cells deploy from the lymph nodes to the infected area. They cannot, however, identify the infected cells unless those cells cooperate. The infected cells alert the T cells much as APCs activated the T cells; they display viral particles on their cell surfaces. Now, however, the T cells do not need co-stimulatory signals. Having only recognized the displayed pathogen antigen, they will “kill infected targets with great precision, sparing adjacent normal cells. This precision is critical in minimizing tissue damage while allowing the eradication of infected cells.”<sup>26</sup>

Infected cells actively participate in their own deaths; a killer T cell does not “kill” in a conventional sense. Rather, it activates within the target cell a genetic program that signals the cell to kill itself.<sup>27</sup> Calling this “sacrifice” for the good of the cellular community is too anthropomorphic; yet, “sacrifice” illustrates the effect. The cell would, in most cases, fall victim to the virus anyway. The virus and its offspring would then infect and kill many more. Thus, the precise, coordinated, and highly regulated immune response may cause relatively few cell deaths early in the infection but preserve the lives and functions of not only many more cells but also the body itself.

After the effector cells clear the infection, then the body clears the effector cells. “The actions of effector cells remove the specific stimulus that originally recruited them. In the absence of this stimulus, they then

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<sup>25</sup> These intracellular pathogens are most often viruses rather than bacteria. Viruses hijack the body’s cells and then use the cell’s genetic machinery to produce more viruses.

<sup>26</sup> Janeway et al., 333. The T cell only recognizes antigen when bound to special receptors on the body’s own cells. It cannot, therefore, recognize antigen that is, for instance, floating in the bloodstream. B cells thus perform that role.

<sup>27</sup> This process is called apoptosis, or programmed cell death; the professional literature often refers to it as “cell suicide.” It serves many biological purposes aside from the one mentioned here. The biochemical mechanisms are incredibly complex and beyond the scope of this discussion.

undergo ‘death by neglect.’”<sup>28</sup> Perhaps the energy expenditure to maintain these cells is too great, or maybe an enormous population of highly lethal cells, which must be tightly controlled, patrolling the body constantly, presents an unacceptable risk. For whatever reason, the body drastically scales back its response force. It destroys, for instance, over 90% of the effector T cells.<sup>29</sup> How then does the body stand ready for another attack by that same pathogen? It remembers. Some of the effector cells do not die; they differentiate into memory cells.

A memory cell does not remember “disease,” or “illness,” or even a specific set of symptoms. It remembers an antigen, which is associated with a pathogen, which caused some set of symptoms, which the afflicted call “disease.”<sup>30</sup> Memory allows the adaptive system, should it again encounter that antigen, to bypass the time-consuming recognition by and activation of naïve cells. Thus, any subsequent, or secondary, exposure to a given antigen produces a much more rapid and pronounced immune response than did the initial, or primary, exposure.

A case of simultaneous antigen exposure best illustrates the specificity of this enhanced response. If, for instance, a person simultaneously experiences secondary exposure to antigen A and

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<sup>28</sup> Janeway et al., 401.

<sup>29</sup> Jonathan Sprent and David F. Tough, “T Cell Death and Memory,” *Science*, 13 July 2001, 246.

<sup>30</sup> Think of antigen as a chemical fingerprint, the lymph nodes as a central processing station, and the collection of naïve T cell and B cell receptors as a database. In this case, the database does not contain prints of known perpetrators; the innate system and the memory T cells and B cells form those databases. Rather, the adaptive system’s naïve database once contained all possible fingerprints. However, the fingerprint of each person who is verified as a law-abiding citizen (self antigens, food antigens) is either removed from the database or labeled as not warranting concern. Should those prints subsequently be compared to the database, they would come back as “no match” or “tolerated match” and thus not be considered a threat. Should, however, the forwarded fingerprint match one in the database, then its owner is automatically considered a potential threat. Additional evidence or circumstances (the second, or co-stimulatory, signal) would then confirm that the person was an actual threat. The immune system is not the perfect protector. Problems can and do arise. For example, the mechanisms to screen non-threatening matches from the database can break down and subsequent, erroneous “matches” may falsely indict someone. Some law-abiding citizens can become criminals (normal cell becomes cancerous). Some microbes can change their “fingerprints.”

primary exposure to antigen B, then the body will respond quickly and strongly to A and much more slowly and weakly to B. The person will likely not get ill from the pathogen that carries antigen A but very well may from a different pathogen that carries B. The differential response times and magnitudes—and the illness that may or may not result—reflect the specificity of immune memory. This memory effect is simply a convenience if the attacking pathogen can, at its worst, induce only cold-like symptoms. Should, however, the pathogen prove lethal, then survivors of that first attack benefit greatly from enhanced protection against a second.

The adaptive system must both identify and react while under attack. Yet, it neither knows what threats it will face nor the timing of future attacks. Moreover, it lacks the luxury to initiate attack—it must always react. Success thus depends on its extraordinary array of recognition receptor capabilities; its rapid expansion once one of these recognition capabilities identifies a threat; its lethal effectors, tailored to target that specific threat; its memory, tasked to remember the now-eliminated threat. Should “disease” again strike, does that then mean immune memory failed? Many “half entertained the vain hope that they were for the future safe from any disease whatsoever.”<sup>31</sup> Should the same symptoms again appear, has memory faltered? Many distinct pathogens produce like symptoms. Should the same pathogen again successfully strike, now may memory be blamed? Same pathogen in name, but is the antigen still the same? There is only memory of what has been seen. To expect otherwise is to fall captive to an illusion of immunity.

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<sup>31</sup> Thucydides, 2.51.6.

## When Immunity Fails

*Now, many nations are trying hard to do the right thing, to improve their border security, to enforce their laws, to improve their ability to track terrorists in their movements and finances. And the United States is actively helping countries to improve their immune systems against terrorism.*

—Condoleezza Rice, US National Security Advisor  
White House Press Release  
1 February 2002

Immunity arises from a system in “delicate balance.”<sup>32</sup> We may wish for improved vigilance, increased lethality, or more immediate response, but we should remember, “. . . beneficial immune protection has had to develop in equilibrium with the potentially lethal damage that immune responses can cause.”<sup>33</sup> While “constant bidirectional cross-talk” between innate and adaptive immunity help maintain the equilibrium, some damage arises unavoidably as a side effect of a robust and normal immune response.<sup>34</sup> Infected tissue becomes inflamed. Some destructive mechanisms target less precisely than others. Even the precise killer T cell attacks may kill so many infected cells as to impair organ function.

Not all immune-mediated destruction falls, however, under this “collateral damage” rubric. Sometimes the finely balanced system goes awry and turns its destructive powers against healthy cells and invaders alike.<sup>35</sup> Infections predispose a person to these adverse reactions; one leading idea suggests that these are cases of mistaken identity. Certain microbe antigens might so closely resemble self-antigens that the

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<sup>32</sup> Pamela L. Schwartzberg, “Tampering with the Immune System,” *Science*, 13 July 2001, 228.

<sup>33</sup> Zinkernagel and Hengartner, 251.

<sup>34</sup> Abbas and Lichtman, 23.

<sup>35</sup> Abbas and Lichtman, 178. Each is also believed to involve genetic predisposition; we see the damage in conditions such as insulin-dependent diabetes and rheumatoid arthritis.

immune system cannot distinguish between the two.<sup>36</sup> Once the immune system responds to the microbe, the persisting memory cells will encounter look-a-like self-antigen and mistakenly interpret its presence as signs of another microbe attack—and thus attack the presumed threat.

While reaction against “self” is somewhat rare, the immune system frequently overreacts to normally harmless, foreign substances—with potentially fatal results. We know this hypersensitivity as “allergies.” Generally, those without allergies produce low-grade immune responses to common allergens, such as cat dander, dust mites, and pollen. The allergic individual, however, generates a vastly exaggerated response. This immune response and not the otherwise innocuous foreign “invader” produces the symptoms.<sup>37</sup>

Finally, while some immune systems respond inappropriately, others respond insufficiently. The problem most commonly stems from immune system immaturity; it is not fully formed at birth.<sup>38</sup> The developing human body thus needs help; it obtains aid through passive transfer of some protective measures from the mother. The child obtains, for instance, antibodies from the mother’s developed immune system both through the placenta and from milk. The effect is the same—a temporary boost in the ability to ward off infection until the immune system can protect on its own.

Some systems, however, never fully develop or maintain this ability; they lack proper resources. In rare cases, genetic conditions may leave the system without key immune responders, such as B cells or T

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<sup>36</sup> Abbas and Lichtman, 182.

<sup>37</sup> Allergy review in A. B. Kay, “Allergy and Allergic Diseases,” *N. Engl. J. Med.* 344, no. 1 (4 January 2001): 30–37. While the common symptoms are often tolerable, for those with certain drug and food allergies, death may rapidly result after exposure. Some studies indicate that increased exposure to microbes while young may stimulate immune responses that make one less allergy prone. This could explain why allergies are more common in the developed world than the developing and why the incidence of allergies and asthma is rising in Western nations.

<sup>38</sup> Some immune processes may take two or more years to fully develop.

cells. More often, ineffective immune responses result from inadequate nutrition—protein malnutrition is the leading form of immunodeficiency.<sup>39</sup> This malnutrition-induced immunodeficiency sets up a vicious cycle: malnutrition increases susceptibility to infection. Infection may further depress the immune response. Some infections can increase loss of nutrients. Immunity becomes further depressed. Treating the patient for the specific infection may help in the short term, but it will do little for the long. The problem must ultimately be treated at its root—genetic deficiency, malnutrition, chronic infection, or other cause. Otherwise, only a continuing battle against a cycle of infections awaits.<sup>40</sup>

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<sup>39</sup> Protein malnutrition chiefly causes a deficiency in T cell production and function.

<sup>40</sup> Armond S. Goldman and Bellur S. Prabhakar, "Immunology," in Baron, 2-34.

## Emerging Disease

*A generation ago, some policymakers suggested that the time had come to "close the book" on infectious diseases. With the availability of a growing arsenal of antibiotics and vaccines, and the eradication or near-eradication in developed countries of diseases such as smallpox, polio and diphtheria, it was argued that biomedical research resources should be diverted from infectious diseases to other concerns. . . . the folly of this position has become clear.*

—Anthony S. Fauci, M.D.  
Director, National Institute of Allergy and Infectious Diseases  
January 1998

*My hope is that all nations will heed our call, and eliminate the terrorist parasites who threaten their countries and our own.*

—President George W. Bush  
State of the Union Address  
January 2002

We often associate this cycle of infection with poverty, an observation that others made long ago. While we know now that malnutrition and lack of clean water and proper sanitation account for much disease among the impoverished, many once attributed disease to miasma—the foul smell and filthy environment—that often accompanied poor people, particularly in early industrial cities. Consequently, activists pushed to remove the filth. They cleaned. Infectious disease declined. Their methods worked—but for reasons scientists would only later discover.<sup>41</sup>

While the sanitarians cleaned and the industrial nations became wealthier, numerous factors contributed to healthier and longer lives: improved nutrition and housing, less-contaminated food and water,

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<sup>41</sup> For the only comprehensive, single volume history of American public health, see John Duffy, *The Sanitarians: A History of American Public Health* (Urbana, IL: University of Illinois Press, 1992). For a comprehensive history of international public health, see the classic volume by George Rosen, *A History of Public Health*, exp. ed. (Baltimore, MD: Johns Hopkins University Press, 1993). Both books are exceptionally readable.

improved sanitation and personal hygiene.<sup>42</sup> Nonetheless, infections exacted a monstrous toll. Even within the wealthy US, tuberculosis, pneumonia, and diarrheal diseases were, as late as 1900, the top three killers and accounted for thirty percent of all deaths.<sup>43</sup> Still, infectious disease was by that point already on the decline.

The scientific, technological, and social advances of the late nineteenth to mid-twentieth centuries allowed industrialized societies essentially to vanquish many illnesses. Vaccination, which mimics an infection so as to induce immune memory, eradicated smallpox worldwide. The US witnessed nearly a 100 percent decline in polio; 99 percent in measles, mumps, and rubella; 97 percent in whooping cough.<sup>44</sup> In an age of antibiotics and advanced medical care, few in the industrialized countries fear, as did earlier generations, that their children may die of diarrhea. These advances were sufficiently along in the developed countries by the late 1960s that the US Surgeon General declared it time to close the book on infectious disease and concentrate on ailments like heart disease and cancer. He spoke too soon; the microbes forced the book back open.

New diseases emerged; once-controlled diseases again raged. Ebola virus, Hantavirus, Lyme's and mad cow diseases appeared. HIV ravages entire villages in sub-Saharan Africa. Cholera, yellow fever, dengue fever, malaria, and tuberculosis resurge around the globe.<sup>45</sup> The World Health Organization reported that three diseases alone—malaria,

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<sup>42</sup> Mitchell L. Cohen, "Changing Patterns of Infectious Disease," *Nature*, 17 August 2000, 762–67. Interestingly, the decline for several diseases began before anyone knew of their microbial origins. We know now that the improved living conditions enabled by wealth and government action boosted people's immune systems and decreased their exposure to pathogens. A very clear lesson also emerged: effective prevention does not always demand knowledge of a cause.

<sup>43</sup> Cited in Cohen, 762.

<sup>44</sup> Cited in Gordon Ada, "Vaccines and Vaccination," *N. Eng. J. Med.* 345, no. 14 (4 October 2001): 1042.

<sup>45</sup> For more detailed information about each disease, see the on-line facts sheets at the World Health Organization and at the US Centers for Disease Control and Prevention: <http://www.who.int/inf-fs/en/index.html>; and <http://www.cdc.gov/health/default.htm>.

tuberculosis, and HIV—killed 5.7 million people in 2001.<sup>46</sup> Even in the US infectious disease deaths climbed 58 percent between 1980 and 1992.<sup>47</sup> So much for vanquished foes.

What went wrong? We changed; the microbes changed. Consider first the human side. The US Institute of Medicine (IOM) identified human demographics and behavior, technology and industry, economic development and land use, and international travel and commerce as, in part, responsible.<sup>48</sup> Increased population density and urbanization returned unsanitary conditions to many cities. Medical care in the developed nations increased the number of people living with immunosuppression (the elderly, cancer patients, sufferers of various chronic diseases, organ transplant patients), who are then more susceptible to acquire and pass infections. Medical care in hospital settings further contributes: nearly two million US patients acquire infections while being treated for other conditions; nearly eighty-eight thousand of them die each year.<sup>49</sup> The sexual revolution brought

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<sup>46</sup> See World Health Organization, *Scaling Up the Response to Infectious Diseases* (Geneva: World Health Organization, 2002). On-line. Last accessed, 20 June 2002. Available from <http://www.who.int/infectious-disease-report/2002/framesintro.html>.

<sup>47</sup> Cited in Centers for Disease Control and Prevention (CDC), *Emerging Infectious Diseases: A Strategy for the 21<sup>st</sup> Century* (Atlanta, GA: CDC, 1998), 1. On-line. Last accessed, 20 June 2002. Available at <http://www.cdc.gov/ncidod/emergplan/plan98.pdf>. To keep the increase in perspective, however, one should note that the mortality rate in 1992 was only about 60 per 100,000. Contrast this with the 1900 rate of over 500 per 100,000 and the rate of over 800 per 100,000 during the flu pandemic of 1918.

<sup>48</sup> Joshua Lederberg, Robert E. Shope, and Stanley C. Oaks Jr., eds., *Emerging Infections: Microbial Threats to Health in the United States* (Washington D.C.: National Academy Press, 1992), 108. Available from the National Academy Press website: <http://www.nap.edu/catalog/2008.html>.

<sup>49</sup> Aside from the human toll, these hospital-acquired infections cost Americans over five billion dollars annually. Centers for Disease Control and Prevention, "Hospital Infections Cost U.S. Billions of Dollars Annually," 6 March 2000. On-line. Last accessed, 20 June 2002. Available from <http://www.cdc.gov/od/oc/media/pressrel/r2k0306b.htm>. In another example of the collateral damage from medical care, one study cautiously concluded that over 100,000 people in the U. S. die each year from prescription drug-related deaths. If true, then this would be the fourth to sixth leading cause of death in America. Jason Lazarou, Bruce H. Pomeranz, and Paul N. Corey, "Incidence of Adverse Drug Reactions in Hospitalized Patients: A Meta-Analysis of Prospective Studies," *J. Amer. Med. Assoc.* 279, no. 15 (15 April 1998): 1200–1205.

increases in sexually transmitted diseases, most notably HIV. Air conditioners and tampons gave us Legionnaire's disease and toxic shock syndrome. Reforestation of vast segments of the US supported increasing deer populations and Lyme's disease.

Americans long enjoyed relative isolation from foreign disease threats—no longer. International travel and commerce allow global disease transmission. Wide-scale importation, for example, of fresh fruits and vegetables brings the bacteria of the exporting land. Moreover, the half billion people who enter our borders every year are potential disease incubators—as we are when we cross theirs.<sup>50</sup> Many more examples exist, but the message is clear: societal and technological progress pushed diseases into decline; societal and technological progress helped them reemerge in unexpected ways.

The microbes play active roles in the emerging change. They evade immune detection by changing their antigenic appearance.<sup>51</sup> They mutate and resist antibiotic action: “Once an antibiotic is proven effective and enters widespread human therapeutic use, its days are numbered. . . . Development of resistance is not a matter of if but only a matter of when.”<sup>52</sup> Moreover, antibiotic resistant bacteria can pass their resistance genes to bacteria of other species, with many becoming resistant to multiple antibiotics.<sup>53</sup>

Unintended consequences of progress and the ever-adapting microbes explain much of the emerging threat. Still, humans share culpability. Overuse of antibiotic weapons, for example, particularly

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<sup>50</sup> For more homeland security facts see <http://www.whitehouse.gov/response/>.

<sup>51</sup> They may, for instance, change the antigens that they display to the immune system. Because of this antigenic change you must, for instance, get different flu shots each year. The artificially induced immune memory from previous shots will often not protect you from the changing flu virus.

<sup>52</sup> Christopher Walsh, “Molecular Mechanisms that Confer Antibacterial Drug Resistance,” *Nature*, 17 August 2000, 776–77.

<sup>53</sup> For more information on microbial genetics, see Claire M. Fraser, Jonathan A. Eisen, and Steven L. Salzberg, “Microbial Genome Sequencing,” *Nature*, 17 August 2000, 799–803.

when used in subtherapeutic doses, breeds microbial resistance.<sup>54</sup> More pointed is the observation of the IOM study:

There can be a delicate balance between maintaining control of a disease and the initiation of an epidemic. It is one thing to have this balance disrupted by essentially uncontrollable elements; it is quite another to have it go awry as a result of individual or organizational complacency.<sup>55</sup>

Complacency set in after our early successes with antibiotics and vaccines. Public health and medical officials began losing interest in the 1950s and 1960s. Vaccination rates dropped.<sup>56</sup> Our public health infrastructure eroded. Some might argue that we practically invited the microbes back into the fight.

While the emerging threats capture our attention and channel our efforts now, they may not hold our focus for long. The history of American public health shows three broad trends extending back to colonial years:

Among the themes that seem to run through American public health history, possibly the most striking one is the constant alteration between apathy and sharp reaction to public health crises. . . .

The fight to replace ineffective traditional ways of maintaining health with more effective ones is another constant in public health history. . . .

Another recurrent theme in American public health is the clash between individual liberty and the public welfare, as government attempts to regulate human conduct in accordance with the prevailing principles of community health.<sup>57</sup>

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<sup>54</sup> Walsh, 777.

<sup>55</sup> Lederberg et al., 108.

<sup>56</sup> In 1990, for example, nearly all Central and South American countries had higher measles vaccination rates than the US. Cuba's rate stood at 94 percent; the US at 70. See Lederberg et al., 109.

<sup>57</sup> Duffy, 2-3.

Segments of society vigorously opposed, and still do in some cases, many of today's commonplace protective and preventive measures—sewers; mandatory vaccines; clean water, food, and air standards; food service regulations; and pasteurization. Most take these measures for granted, seldom aware of the extent to which they permeate our daily lives. If only much of the world could do the same. For several generations of Americans the specter of widespread death from infectious disease is something new. But, for many people outside these borders it is an old and never-ending fight.

## Chapter 3

### Threats from Within

*We share the belief that terrorism is a cancer on the human condition, and we intend to oppose it wherever it is.*

—Donald H. Rumsfeld, US Secretary of Defense  
Announcement of US military operations in Afghanistan  
7 October 2001

*Well, terrorism is the cancer of our age . . . . For the past decade, a lot of countries wanted to deny that, or make excuses for why they could go on dealing with terrorists. But after what's happened in New York and Washington, now everyone knows. This is a cancer. It's a danger to us all. So every country must now decide whether it wants to be a smoking or non-smoking country, a country that supports terrorism or one that doesn't.*

—Shimon Peres, foreign minister of Israel  
Reported by NY Times columnist Thomas Friedman  
14 September 2001

Cancer is the renegade of cellular society.<sup>1</sup> It subverts the body's normal order of cooperation and communication.

Our bodies are nothing more than highly complex societies of rather autonomous cells, each retaining many of the attributes of a fully independent organism. . . . When, as usually happens, these cells are well-behaved and public-spirited, extraordinarily complex order ensues. But on occasion, a cell may choose to go its own way and invent its own novel version of a tissue or organ. It is then that we see the much-feared chaos that we call cancer.<sup>2</sup>

This chaos of cancer begins with the distortion of a cell's genetic message, with the cell's subsequent behavior gone awry.

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<sup>1</sup> I borrowed "renegade" from Robert A. Weinberg, *One Renegade Cell* (New York: Basic Books, 1998). This book, written by an internationally known cancer researcher, provides an exceptionally readable yet scientific account of how cancer begins.

<sup>2</sup> Weinberg, 2.

## The Nature of the Adversary

*We knew we had cancer. Now we know it has metastasized. The Al Qaeda terrorist network reached into the very systems of cooperation and communication . . . and turned the building blocks of peace into the weapons of war.*

—John D. Negroponte, US Permanent Representative to the UN  
Statement in the UN General Assembly's Plenary Session on  
Terrorism  
1 October 2001

The genes encoded in a cell's DNA shape how that cell interacts with other cells and substances in the environment and, consequently, how that cell develops and behaves. All cells in a given human body carry identical sets of genes, but cells differ as to which of these genetic instructions they read and respond to. This selective reading of the DNA text and its resultant effect on cellular development and behavior produces diverse cell types. It makes, for example, nerve cells different from lung cells but nerve cells of a given type very much like each other. The normal cellular order arises, then, because all cells of a given type respond rather consistently to their environment while performing DNA-directed roles within cellular society.<sup>3</sup>

Within this society, cellular communication and cooperation are the norm. Cells grow and produce new cells, for instance, only when they receive signals from neighboring cells instructing them to do so. The cells then generally stop growing and replicating only when other cells send them growth-inhibition signals. Biological factors limit the number of times that a cell can proceed through this growth cycle before it dies. A cell may also die by activation of its built-in death program

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<sup>3</sup> For an undergraduate-level introduction to genetics, see Anthony J. F. Griffiths et al., *An Introduction to Genetic Analysis*, 7th ed. (New York: W. H. Freeman & Co, 1999). Available from <http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=Books>. For a basic science introduction to cancer and related issues, see the National Cancer Institutes "Science Behind the News" at <http://newscenter.cancer.gov/sciencebehind/>.

should the cell's behavior go awry.<sup>4</sup> Finally, cells stay within the confines of their own tissues and do not spread.<sup>5</sup>

A cancer cell violates these norms of cellular behavior. It stimulates its own growth and ignores signals from neighboring cells to stop growing.<sup>6</sup> It evades the mechanisms that trigger death in aberrant cells and may replicate indefinitely. It siphons nutrients and other support from the surrounding cell population and, should it need more, induces the body to produce new blood vessels to supply the growing tumor with additional nutrients.<sup>7</sup> The growing tumor invades nearby tissues; cells separate from it and metastasize, or spread and invade other tissues:

Cells remain confined to their home territory because they are held in check by intercommunication with neighboring cells and with the surrounding extracellular matrix . . . [whereas] malignant tumour cells can be hypothesized as being resistant to the regulatory signals because they may appropriate, misinterpret, or disregard these signals and dominate the local invaded host-cell populations.<sup>8</sup>

The capabilities to proliferate uncontrollably; to appropriate, misinterpret, or disregard regulatory signals; to derive sustenance from

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<sup>4</sup> This is the “cell suicide” program that killer T cells trigger in a viral-infected cell (Chapter 2). In the context discussed above, a cell may initiate this program if, for example, it experiences severe, irreparable problems in its DNA.

<sup>5</sup> Tissue is an aggregate of a single type of cell. Collections of tissues form organs that perform various functions.

<sup>6</sup> It could stimulate its growth by many mechanisms. One suggestion is that the cell triggers its growth without any signaling from neighboring cells. On the other hand, it can induce those cells to unnecessarily release growth signals. The cancer cell would then respond to the signals in normal fashion—grow and replicate. See Douglas Hanahan and Robert A. Weinberg, “The Hallmarks of Cancer,” *Cell* 100 (7 January 2000): 60.

<sup>7</sup> This process of blood vessel formation is called angiogenesis. Once a tumor grows beyond a certain size, the cells in the center of the mass become oxygen starved. By stimulating blood vessel formation into the tumor itself, the tumor satisfies the need for oxygen and continued development. It is an interesting question as to whether this “support” from the normal host cells makes them somehow complicit in the tumor's continued existence.

<sup>8</sup> Lance A. Liotta and Elise C. Kohn, “The Microenvironment of the Tumour-Host Interface,” *Nature*, 17 May 2001, 375.

and dominate the local host-cell population; and to spread to tissues afar—these are the hallmarks of cancer.<sup>9</sup>

Cancer behaves as such because it reads and responds to a corrupted genetic text. The corruption consists of a series of mutations and other genetic modifications, which generally occur over many years and originate within a single cell.<sup>10</sup> The genetic changes launch the cell into the characteristic cycles of uncontrolled cell proliferation, with the body consequently harboring scores of renegade clones. Some of the clones, being renegades themselves, may then diverge from the founder.<sup>11</sup> The malignant tumor contains, consequently, subpopulations of cancer cells—each with a unique genetic message and possessing to varying degrees the hallmark capabilities. These subpopulations compete in Darwinian fashion to become the dominant group within the tumor. A single, cancerous mass may thus prove far more diverse and complex than the homogeneous-sounding name “cancer” implies.

The catch-all name “cancer” masks to an even greater extent the genetic and behavioral diversity among cancers of various types. Many of us view these differences as being largely of disease location—lung cancer, colon cancer, breast cancer, prostate cancer, and so on. While these “all share the ability to proliferate beyond the constraints limiting

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<sup>9</sup> Hanahan and Weinberg, who developed this “hallmark” model, call these the “acquired capabilities of cancer.” They “suggest that most if not all cancers have acquired the same set of functional capabilities during their development, albeit through various mechanistic strategies.” Hanahan and Weinberg, 58.

<sup>10</sup> Cancer does not have a single cause. Rather, numerous risk factors—heredity, life-style, environmental exposure, viral—can trigger mutations in virtually every mammalian cell (hair, nails, and teeth excepted). For on-line information, see the US National Cancer Institute’s Surveillance, Epidemiology and End Results (SEER) Program Training Web Site at <http://training.seer.cancer.gov/>. I reference subsequent material from this site as NCI/SEER (training module name). For more detailed information on cancer genomics, see Lance A. Liotta and Edison T. Liu, “Essentials of Molecular Biology: Genomics and Cancer,” in *Cancer: Principles and Practice of Oncology*, 6<sup>th</sup> ed., edited by Vincent T. DeVita, Jr., Samuel Hellman, and Steven A. Rosenberg, (Philadelphia, PA: Lippincott Williams & Wilkins, 2001), 17–29.

<sup>11</sup> The genome of cancer cells is inherently unstable and undergoes more random genetic changes than do normal cells.

growth in normal tissue,” their differences transcend location.<sup>12</sup> Cancer of the lung and cancer of the breast are not the same disease threat in distinct locations.<sup>13</sup> Even cancers with the same name—prostate cancer, for instance—vary from person to person. Some are aggressive; some grow more slowly. Some quickly spread; some remain relatively contained:

The great majority [of cancer cells] will be ill-suited for the rigors of metastatic voyage and settlement in new terrains, so their attempts to colonize distant sites will end up as suicide missions. By now, the primary tumor mass may have grown quite large and can afford to dispatch a large, continuous stream of scouts on these missions. Even a seemingly impossible mission will succeed if tried often enough, so some new colonies will be founded and then thrive at distant sites. Sooner or later, these metastases begin to compromise the functioning of host tissues in which they have taken root. Only then is the cancer patient placed at death’s door.<sup>14</sup>

Failure to properly assess the nature of this deadly threat “can lead to poor treatment planning and compromise the ability to cure patients.”<sup>15</sup> The physician must, therefore, ask and answer: what—exactly—are the patient and I fighting?

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<sup>12</sup> Gerard I. Evan and Karen H. Vousden, “Proliferation, Cell Cycle and Apoptosis in Cancer,” *Nature*, 17 May 2001, 343.

<sup>13</sup> The common names for cancers indicate where the original tumor originated. If for instance, the tumor originated in the breast and then spread to the brain, the patient would not then have both breast cancer and brain cancer. She would have metastatic breast cancer.

<sup>14</sup> Weinberg, 149. The Merck Manual of Diagnosis and Therapy (available on-line at <http://www.merck.com/pubs/mmanual/>) points to another interesting characteristic of metastases: “Experiments suggest that metastasis is not a random event and that the primary tumor may regulate the growth of metastatic tumors. . . . Theoretically, removal of the primary tumor can result in rapid growth of the metastases.” Merck, Ch 142, no pagination.

<sup>15</sup> Steven A. Rosenberg, “Principles of Cancer Management: Surgical Oncology,” in DeVita et al., *Cancer*, 260.

The “first step in rationally treating” cancer is thus to properly classify the disease.<sup>16</sup> Classification considerations include determining both the extent of tumor spread, the “stage,” and the degree of similarity between cancer and normal cells, the “grade.” Physicians assess the stage by answering three questions. First, how large is the original tumor and to what degree has it invaded the surrounding tissue or organs? Next, has it spread to the regional lymph nodes?<sup>17</sup> Finally, has it metastasized to more distant areas of the body?<sup>18</sup> The greater the spread—the higher the stage—the greater the danger. Microscopic analysis of the cancer cells yields the grade. High-grade cancers tend to grow rapidly and are more resistant to therapy. Together, the stage and grade help physicians assess how near the patient may be to death’s door.

Cancer—a single name that signifies a potentially lethal imbalance in cell society, the gross distortion of cell behavioral norms, the resistance to outside cellular influence. Cancer—one name but many diseases.

Each of the 1,268,000 Americans who will be diagnosed with cancer this year will battle a very specific, very personal disease. While the hundred-plus distinct diseases we call ‘cancer’ have several essential attributes in common, each type of cancer has its own unique characteristics that affect how it arises, how it progresses, and how it can be most effectively treated.<sup>19</sup>

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<sup>16</sup> Carlos Caldas and Samuel A. J. Aparicio, “The Molecular Outlook,” *Nature*, 31 January 2002, 484.

<sup>17</sup> Spread to the regional lymph nodes often indicates distant, unseen metastases.

<sup>18</sup> Although metastases were discovered in the nineteenth century, we still know relatively little about them. Some clinical observations: Metastases do not spread randomly; a certain cancer of the eye, for instance, metastasizes almost exclusively to the liver. In addition, metastases themselves can also later metastasize.

<sup>19</sup> The specific nature of each cancer led the National Cancer Institute (NCI) to promote both general and disease-specific cancer research. National Cancer Institute, *The Nation’s Investment in Cancer Research: A Plan and Budget Proposal for Fiscal Year 2003* (Bethesda, MD: National Cancer Institute, 2001), 93. On-line. Last accessed, 20 June 2002. Available from <http://plan.cancer.gov/pdf/bypass.pdf>.

The nature of the threat thus demands an array of viable treatments.

## **Fighting the Enemy Within**

*The dreadful attacks against [the] WTC and the Pentagon unveil, time and again, that the cancer of terrorism can be extensively damaging if left unchecked. It follows that there is a pressing and urgent need to combat world terrorism.*

—League of Arab States  
Official statement regarding September 11<sup>th</sup> attacks  
17 September 2001

*But what we do want to do, though, is to work with every government in which there is a substantial al Qaeda presence to figure out a strategy for rooting it out. Because it's like cutting out a cancer now in 60-plus countries. You've got to get to these cells and root them out and disrupt them before they strike again.*

—Condoleezza Rice, US National Security Advisor  
White House Press Briefing  
15 October 2001

The treatment strategy is “to choose an approach that will remove the tumor, rid the body of wandering cancer cells, and prevent a recurrence.”<sup>20</sup> Each of the standard cancer treatments—surgery, radiation, and chemotherapy—contributes by eradicating or controlling cancer cells. But each method proves better suited for some cancer conditions than others do.<sup>21</sup> Surgery, for instance, remains the front-line treatment for solid tumors. Radiation complements surgery, but each suffers limitations:

In selecting appropriate therapy, surgery and radiation are still the most successful means of treating cancer localized to the primary site and/or regional lymph nodes. Since these forms of therapy exert their effects locally, neither is usually considered curative once the disease has metastasized beyond the loco-regional site.<sup>22</sup>

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<sup>20</sup> NCI/SEER (Cancer treatment: overview).

<sup>21</sup> This is why staging is so important.

<sup>22</sup> Raphael E. Pollock and Donald L. Morton, “Principles of Surgical Oncology,” in *Cancer Medicine*, 5<sup>th</sup> ed., edited by Robert C. Bast Jr. et al. (Hamilton, Ontario: B. C. Decker, 2000). On-line. Last accessed, 19 June 2002. Available from <http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=Books>.

Chemotherapy takes aim at the wandering cells and thus makes its contributions where surgery and radiation may fail, for “therapy with cytotoxic drugs is the basis for most effective treatments of disseminated cancers.”<sup>23</sup>

The cancer-fighting weapons in the medical arsenal generally work best when they work together; combination therapy—two or more methods—is accordingly much more common than any therapy alone.<sup>24</sup> Combined surgery and radiation, for instance, can complement each other’s effects.<sup>25</sup> Surgery can remove a tumor yet leave microscopic cells behind. Radiation, on the other hand, lacks effectiveness at a tumor’s center but works well at the tumor periphery. Thus, a treatment plan might call for surgery to remove the main tumor and radiation to kill any residual cells.<sup>26</sup> This combination approach can allow for less drastic surgical measures than otherwise necessary and increase the probability of cure. Similar reasons exist to combine surgery or radiation with chemotherapy. The latter is generally ineffective when confronting a large tumor. Surgery and radiation could, however, reduce the main cancer burden. Chemotherapy would then attack any residual,

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<sup>23</sup> Chemotherapy acts systemically—throughout the whole body—as opposed to the local action of surgery and radiation. See, Charles S. Morrow and Kenneth H. Cowan, “Drug Resistance and Its Clinical Circumvention,” in Bast et al. On-line. Last accessed, 20 June 2002. Available from <http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View..ShowSection&rid=cmed.chapter.d1e333588>.

<sup>24</sup> Each therapy can achieve success on its own. Surgery alone, for instance, cures many skin cancers. Radiation therapy can eradicate some forms of breast and prostate cancer. Chemotherapy cures some forms of leukemia. However, some cancers are inoperable, some radioresistant, and some chemoresistant.

<sup>25</sup> For a general discussion of combined uses of radiation with other treatments, see Samuel Hellman, “Principles of Cancer Management: Radiation Therapy,” in DeVita et al., *Cancer*, 285–86.

<sup>26</sup> Just a note for some in the military audience: Given that a cure is impossible without eradicating all of the cancer cells, ask yourself which treatment is the dominant or more decisive one. Is it the surgery, which removed, say, 95 percent of the cells? Alternatively, is it the radiation, which killed the rest? The patient might think it a silly or even meaningless question.

metastasized cells.<sup>27</sup> In a different form of combination therapy, a physician might use two therapies to attack the same cells. Some forms of chemotherapy, for instance, make cancer cells more susceptible to radiation.<sup>28</sup> Subsequent radiation treatment then proves more effective than radiation alone.

A physician must consider more, however, than the threat and potential cure. He must also consider risk—that of treating too aggressively versus the chance of not treating effectively at all. Patients respond differently to the same treatments. Identical radiation or chemotherapy treatments for identical cancer types and locations can, for instance, produce very different side effects—both in terms of type and severity—in different people. The side effects, indicative of radiation and chemotherapy toxicity to normal cells, range from relatively minor to significant: hair loss, nausea and vomiting, fatigue, reproductive dysfunction, damage to healthy cells.<sup>29</sup> Additionally, both chemotherapy and radiation may increase a patient's risk of developing a second cancer.<sup>30</sup> Finally, too high a drug dosage can prove lethal.<sup>31</sup>

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<sup>27</sup> Even with chemotherapy, the “complete eradication of metastatic disease by currently [2001] available therapeutic strategies [is] extremely difficult.” Moreover, ninety percent of drug cures occur in just ten percent of cancer types. William G. Stetler-Stevenson and David E. Kleiner Jr., “Molecular Biology of Cancer: Invasion and Metastases,” in DeVita et al., *Cancer*, 123; and Edward Chu and Vincent T. DeVita Jr., “Principles of Cancer Management: Chemotherapy,” in DeVita et al., *Cancer*, 290.

<sup>28</sup> Hellman, 286.

<sup>29</sup> Michael B. Kastan and Stephen X. Skapek, “Molecular Biology of Cancer: The Cell Cycle,” in DeVita et al., *Cancer*, 107. Radiation kills both healthy and normal cells. Chemotherapy damages healthy cells, but they generally can repair themselves. Physicians thus will often use the maximum safe dosage even in the presence of side effects because they are generally temporary.

<sup>30</sup> This produces an interesting predicament: the treatment that saves you now may generate worse circumstances and kill you later. If you do not take the treatment now, however, you may never live to worry about a second cancer. The increased risk of second cancers inherent in certain treatments must be balanced against several competing factors: age of patient, severity of illness, likelihood of improved survival from treatment, and so on. The efficacy of treatment of the first cancer is the primary concern. Flora E. Van Leeuwen and Lois B. Travis, “Second Cancers,” in DeVita et al., *Cancer*, 2939, 2960.

<sup>31</sup> Even while surgery avoids the toxicity side effects, it introduces other drawbacks—loss of organ function a prominent one as seen in hysterectomies and mastectomies, for

Seeking to avoid the undesired and sometimes devastating damage that treatment can impose, physicians over the years developed more precise ways to target cancer cells while sparing healthy ones. Surgery, for instance, was likened by a famed eighteenth century practitioner of the art to “an armed savage who attempts to get that by force which a civilized man would get by stratagem.”<sup>32</sup> Surgery is now far less a brute force strategy. Advanced surgical techniques and technologically sophisticated tools (laser surgery, for example) allow precision that early practitioners would find unfathomable. Radiation therapy may also precisely target cancer cells: “The goal of treatment planning is to uniformly irradiate a specified target while minimizing the dose to surrounding normal tissue.”<sup>33</sup> These refined, brute force approaches may minimize, to the extent technologically possible, the collateral damage to tissue in the immediate area of a localized tumor. But precision is relative. Compared to older surgical and radiation tools and procedures, the new methods are incredibly precise. Compared to needs—to find and eradicate small pockets of metastasized cells that mix with healthy ones—the precision offers relatively little help. For the metastases, therefore, physicians often turn to chemotherapy; yet, precision targeting with chemotherapy also proves problematic.

In developing precision chemotherapeutic agents, “The critical issue is to identify how tumor cells differ from normal cells and how those differences can be exploited therapeutically.”<sup>34</sup> Cancer exacerbates this problem because the once-normal rogue cells retain most of their normal features. The resultant drug-targeting difficulties explain why

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example. One benefit of surgery, however, is that the surgeon can often reconstruct what he or she damaged with curative surgery.

<sup>32</sup> Quoted in Rosenberg, 261.

<sup>33</sup> Arno J. Mundt, John C. Roeske, and Ralph R. Weichselbaum, “Physical and Biologic Basis of Radiation Oncology,” in Bast et al. On-line. Last accessed, 20 June 2002. Available from <http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View.ShowSection&rid=cmed.section.d1e274582>.

<sup>34</sup> Evan and Vousden, 343.

metastasis is the chief reason for cancer deaths and treatment failure.<sup>35</sup> Precision and effectiveness largely elude us when the renegade cancer cells disperse, prove difficult to locate, and intermingle with healthy cells.

This may soon change. The problem remains one of finding ways to precisely target diseased cells with fewer side effects to the healthy, but the phenomenal gains in understanding of the genetic differences between normal and cancer cells provide promising prevention and treatment opportunities. On the prevention side, molecular diagnostics—characterizing a cancer by its genetic fingerprints—could revolutionize care.

For most people, the diagnosis of cancer comes unexpectedly. But as scientists have learned, the cellular changes that lead to cancer probably have been developing slowly in a person's body over several decades. This discovery raises a window of opportunity to catch the cancer cells before they ever become a threat to a person's health.<sup>36</sup>

We already glimpse this potential as physicians identify people with genetic predispositions to certain cancers and provide the option to act before the potentially deadly threat emerges.<sup>37</sup> Some women with family histories of ovarian or breast cancer, for example, opt for hysterectomies or mastectomies.

Still, the decision to preempt cancer may not always prove easy. When facing a high probability of fighting a deadly, treatment-resistant cancer, the decision to opt for preventive surgery is relatively easy, particularly if the risk and side effects are acceptable. The decision would become vastly more complicated, however, if confronting less lethal or less probable cancers, particularly if the surgery is risky or if

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<sup>35</sup> The patients die from organ failure associated with the disease or from systemic treatments directed at the disease. Stetler-Stevenson and Kleiner, 123.

<sup>36</sup> NCI "Future Plans" fact sheet. On-line. Last accessed, 20 June 2002. Available from <http://cra.nci.nih.gov/index.shtml>.

<sup>37</sup> *Ibid.* The assessment of risk is extremely difficult. Susceptibility genes and environmental factors—within the body and without—interact in mostly unknown ways.

the cancer type is often—but not always—treatable.<sup>38</sup> Moreover, once you took action, you would never know whether the threat might have materialized nor to what degree—and what did you lose to the surgery?

Should cancer arise, however, the increasing ability to collect and analyze genetic information about a particular cancer may make it easier to diagnose and effectively treat. Medical imaging techniques revolutionized medical care, and the ability to refine images to the molecular level would revolutionize diagnostic procedures again. New precision targeting treatments “enlist a patient’s immune defences in fighting cancer.”<sup>39</sup> With such immunotherapy, “toxins can be linked to [certain types of] antibodies. This converts the antibodies into ‘smart bombs’ that guide the toxins to the tumor cell targets.”<sup>40</sup> Cancer vaccines offer the promise of the body protecting itself, as they try to stimulate the immune system to attack cancer cells. Some gene therapies even attempt to convert a cancer’s distorted genetic message by inserting the proper genetic information.<sup>41</sup>

Even the old tool of chemotherapy is being transformed. New drugs try to attack cancer’s ability to induce blood vessel formation, effectively interdicting the tumor’s nutrient and oxygen supply lines. Others try to disrupt the internal signals that govern a cancer cell’s spread. More weapons are on the way:

We are entering an era in cancer research that holds the potential for an exciting new approach to drug development for cancer prevention and treatment. These drugs will be designed to target specific molecular features of cancer cells, such as small but critical errors in genes or proteins that

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<sup>38</sup> For examples of the uncertainty associated with early detection and prevention measures, see Gina Kolata, “Test Proves Fruitless, Fueling New Debate on Cancer Screening,” *New York Times*, 9 April 2002.

<sup>39</sup> Drew Pardoll, “T cells and Tumours,” *Nature*, 28 June 2001, 1010.

<sup>40</sup> Weinberg, 160.

<sup>41</sup> The difficulty is in achieving this genetic conversion in all of the cancer cells present. Interestingly, scientists are using one human threat to combat another: viruses serve as one of vehicles, or vectors, to insert the desired genes into cancer cells.

lead to tumor growth. By selectively attacking cancer cells, these revolutionary agents promise to be less toxic and more effective than current drugs. This extraordinary opportunity of molecular targeting has been generated by knowledge . . .

<sup>42</sup>

It has been generated by knowledge that cancer is not one threat from within but many, by knowledge of the genetic message at the heart of the renegade cell, and by knowledge that adds new tools and transforms our old tools to tackle new tasks.

The example of the recently approved drug Gleevec offers insight into both the promise and drawbacks of the emerging precision-targeting approaches. Gleevec attacks a single, vital molecular target in a particular form of leukemia. During clinical trials, 98 percent of patients with an early stage of leukemia responded positively within three weeks of treatment; all remained in remission during the nearly yearlong follow up. Among those in various later stages of the disease, between 55 and 70 percent went into remission; however, nearly all relapsed within a few months. A single mutation in the cancer cells caused the relapse—the molecular target mutated and endowed the cancer with resistance.<sup>43</sup>

Cancer cells, like any determined adversary, will resist, adapt, regroup, and re-attack. When Gleevec attacks a single, vital, cell target, those cancer cells that adapt will survive. The drug resistant cells remain; the vulnerable ones die. Eventually the tumor regrows, with the resistant cells dominant.<sup>44</sup> Administration of another drug in sequential fashion could produce the same resistance effect. An alternative approach might call for a simultaneous targeting strategy—the targeting of many cancer cell mechanisms simultaneously with a combination of drugs, each designed to strike a specific cell mechanism. Alternatively,

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<sup>42</sup> NCI, *Nation's Investment*, 78.

<sup>43</sup> Brian J. Druker, "STI571 (Gleevec) as a Paradigm for Cancer Therapy," *Trends in Molecular Medicine* 8, no. 4 (1 April 2002): S14–18.

<sup>44</sup> Evan and Vousden, 347.

“several drugs that hit different parts of the same target might be ideal” because cancer cells resistant to one of the drugs would unlikely be resistant to all.<sup>45</sup> A promising outlook, but cancer has dashed many promises and hopes.

When President Nixon signed the National Cancer Act of 1971, he made the “conquest of cancer a national crusade.”<sup>46</sup> A supportive nation readily embraced the act’s promise and followed Nixon into the newly declared “war on cancer.” What the nation declared war against was, as we now know, not a single disease but a concept, one of cancer as an aberrant and unwanted condition of the human body. It was a new war against an old enemy, but it was an enemy little understood at the time. At the signing ceremony, President Nixon, perhaps waxing rhetorical, put the crusade into perspective: “I hope in the years ahead we will look back on this action today as the most significant action taken during my Administration.”<sup>47</sup> Perhaps one day we will; we have seen many successes since that year. For now, however, the war on cancer drags on into its fourth decade.<sup>48</sup> The verdict is out as to whether we are winning.

The data are mixed. On the downside, cancer accounts for nearly ten percent of all disease-related treatments in the US.<sup>49</sup> Its overall economic costs tallied slightly more than \$180 billion in 2000—enough money to fund the nation’s traditional war-fighting requirements for six months. It is currently the second leading cause of US deaths; by 2010, it may surpass heart disease as the leading. Cancer claims the lives of more women aged thirty-five to seventy-four than does any other disease. Although rare in children, cancer still takes those under age 15 at a rate second to no other disease. Every thirty seconds, another American

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<sup>45</sup> Frank McCormick, “New-Age Drug Meets Resistance,” *Nature*, 19 July 2001, 282.

<sup>46</sup> Quoted in National Institutes of Health, “Executive Summary: National Cancer Act of 1971.” On-line. Last accessed, 20 June 2002. Available from <http://www.cancersource.com/nclac/1971canceractsummary.doc>.

<sup>47</sup> Quoted in NCI/Seer (Cancer as a Disease: War on Cancer).

<sup>48</sup> The goal in 1971 was to defeat cancer in five years. NCI, *Nation’s Investment*, 98.

<sup>49</sup> All data in this paragraph from NCI/SEER (Cancer as a Disease: War on Cancer).

hears the cancer diagnosis; every three minutes, two of the stricken will die.

Hopeful signs do exist. Both cancer incidence and death rates peaked in the early 1990s and now move downward, slightly but down nonetheless.<sup>50</sup> More people survive cancer than ever before.<sup>51</sup> Physicians cure about half of all patients.<sup>52</sup> New treatments, the fruits of research in the 30-year cancer war, promise to grant life to even more. Still, the war drags on.

When will the war on cancer be won? How will one know? When can victory be declared? Will it be when more cancers are prevented than need treatment? How does one know how many cases were prevented? Will the war be won when most cancers are eradicated but some few others remain resistant? How many types? Will the war be won when most cancers can be maintained in a chronic state? When cancer kills only 300,000 Americans each year rather than 500,000? When HIV/AIDs or another disease overtakes cancer as chief villain and the medical community shifts focus? Perhaps one can only know when the war is won in hindsight. Still, even if the war on cancer is someday declared over and won, deadly malignancies will occasionally arise. The permanent elimination of all types of cancer seems naively remote. And what of the case of remission from a metastasized cancer? Can one truly know that all of the cancer cells are forever gone and thus will not again threaten? What you do is wait. You hope. You remain vigilant. And you go on living.

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<sup>50</sup> The incidence and death rates climbed 45 and 10 percent, respectively, from 1950 to 1990. They dropped 6.4 and 2.4 percent, respectively, from 1992 to 1996. NCI, "Types of Cancer." On-line fact sheet. Last accessed, 20 June 2002. Available from <http://cra.nci.nih.gov/index.shtml>.

<sup>51</sup> The five-year survival rate increased from 35 percent to 60 percent from the 1950s to the early 1990s. Ibid.

<sup>52</sup> NCI, *Nation's Investment*, 98.

## Chapter 4

### Redefining War

*We are, in a sense, seeing the definition of a new battlefield in the world, a 21st century battlefield, and it is a different kind of conflict.*

—Donald H. Rumsfeld, US Secretary of Defense  
Pentagon News Briefing  
12 September 2001

As the pain of September 11<sup>th</sup> subsides, the fevered demand for justice and a sense of traditional victory lessons as well. Scholars may one day debate whether the event should have triggered a “war” schema at all, but at this point, Michael Howard’s words stand true: “The ‘w’ word has been used and now cannot be withdrawn.”<sup>1</sup> Without doubt, America is at war. Yet, it is not a war that lends itself to any established characterization. In order to be understood fully, it needs to be properly described and classified. But, and herein lies the critical focus of this thesis, can—and should—the “w” word be redefined?

Members of the Bush administration apparently believe so. At the President’s lead they remind us that this is a different kind of war, unlike any other that recent generations faced, and it requires us to think differently. Still, many people naturally grasp for the familiar to help explain and guide when confronting something new. “Pearl Harbor” passed across many lips even before the first World Trade Center tower fell. Yet, as Condoleezza Rice later explained, September 11<sup>th</sup> was no Pearl Harbor—not because the place, means, or human toll differed but because the enemy did: “In that case, we had a country with a capital,

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<sup>1</sup> Howard gives credit to the Bush administration for trying to explain “this will be a war unlike any other, and that they must adjust their expectations accordingly.” Still, he sees the war mentality pushing us inexorably toward major military action. Michael Howard, “What’s in a Name? How to Fight Terrorism.” *Foreign Affairs* 81, no. 1 (January/February 2002): 10.

with marching armies and beaches to storm, and islands to take, and in the last war, deserts to cross. That is not the nature of this war.”<sup>2</sup>

The nature of the enemy and the nature of a war are inextricably linked. Should we now face an adversary with “marching armies and beaches to storm” then we might profitably invoke memories of military victories to explain the task at hand: It will resemble the Gulf War; it will be like Normandy. Of course, it would not be literally so. Details would differ, maybe substantially. The analogies would, however, help explain the general road ahead in familiar terms. They might even suggest for further consideration other issues, each to be subsequently analyzed outside of the analogical frame and in the relevant context. But where should we turn if, as the President has told us, recent military memories will not suffice? Perhaps, as Richard Haass suggests, images from our metaphorical “wars” can hint at explanation, or posit major challenges ahead in the terror war. Perhaps they can suggest areas that merit further study.

Within the current international context, Haass rightly notes that our old language does not fully capture the tasks ahead. Traditional war images—with the promise of high-profile battles and decisive military victories—could produce false expectations in an untraditional war waged covertly, oftentimes with non-military means. A new language will, however, effectively represent the nature of this new enemy and new war only if it resonates with the American people. In an age of bioterror, emerging disease, the human genome, and a metaphorical cancer war, the administration might look further to the language of disease to better communicate the challenges of the war on terrorists.

The infection and immunity metaphors described herein illustrate a threat from without the body, a contagion from “over there.” Infectious

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<sup>2</sup> Condoleezza Rice, “Press Briefing by National Security Advisor, Dr. Condoleezza Rice,” 19 September 2001. On-line. Last accessed, 20 June 2002. Available from <http://usinfo.state.gov/topical/pol/terror/01091921.htm>.

diseases and international terrorists each represent potential global threats. They slip through borders, evade detection, and circumvent protective measures. They often derive resources from their targets, turning a potentially hostile environment to their advantage. Both disease and terrorists kill men and women, old and young, rich and poor alike. Failure to eradicate either could allow the remaining hardy cells to adapt, to resist once-effective treatments, to multiply and strike again, perhaps lethally. New threats of each type, facilitated by technological and social change, can emerge and spread—at the same time old threats reemerge in stronger form—both in unpredictable ways.

The cancer metaphor is about a threat from within, malignants in the global body. Cancer cells and terrorist cells are the renegades of their respective societies. They subvert normality; their distorted internal messages alter behavior in harm-inducing ways. The cancer proliferates uncontrollably; we fear the terrorists also may. Each disregards the regulatory signals sent out from normal neighbors; the renegades instead derive sustainment from and may even dominate those neighbors. Then they spread, often undetectably—and kill indiscriminately.

Parallels also exist beyond the nature of the enemy; they extend to what many foresee as the nature of the war ahead. Protective measures will not, for instance, suffice to counter either the disease or the terrorist killers that can subvert, evade, or rapidly overwhelm even strong defenses. These cases demand prevention or intervention; we must act before attacked. Sometimes, for example, preventive surgery provides the only means to ensure one does not succumb to a specific form of cancer. But, while preemption may sound appealing, in both medicine and war, it can prove difficult; such situations are fraught with risk and uncertainty.

The nature of disease battles and the terror war mirror each other in an even more fundamental way. The core problem in attacking

microbial cells, metastasized cancer cells, and dispersed terrorists cells is the same: to find and selectively target the threatening cells while minimizing damage to healthy human cells or innocent human beings. Whether treating viruses or cancer, this can be a long, difficult, and sometimes insurmountable task. While it appears the problem is essentially similar, we cannot be sure that the prognosis or solutions will so precisely overlap. But the possibility is intriguing. *Might* it be the same for “treating” terrorists?

Additional questions predictably arise when considering the metaphors. Just as various infectious agents, for instance, range from highly lethal to relatively harmless, so also do terrorist groups differ in their capacity to injure. Yet we do not actively seek out and destroy all types of microbes. Some may even be beneficial, strengthening our immunity and symbiotically working to ward off more deadly agents. Should we then seek out and destroy all terrorists? Furthermore, neither all infectious agents nor all terrorists have global reach; each demonstrates patterns of spread—some localized, others global.<sup>3</sup> To which groups should efforts be directed? President Bush noted, “we cannot single handedly wage a successful campaign against international terrorism. In this respect, terrorism is like many other challenges of this globalized era, like combating HIV/AIDS . . . .<sup>4</sup> If our goal is, as the President has said, to eradicate terrorists of “global reach,” do we necessarily then, for sake of attaining international assistance, commit ourselves also to combating terrorists with only local reach, to include those that do not target US citizens or property?<sup>5</sup> How, moreover, do we

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<sup>3</sup> The parallel also arises for cancer, thus the importance of “staging” a cancer to determine the degree of its spread.

<sup>4</sup> Quoted in Richard N. Haass, “The Bush Administration’s Response to Globalization,” 21 September 2001. On-line. Last accessed, 20 June 2002. Available from <http://www.state.gov/s/p/rem/5508.htm>.

<sup>5</sup> For example, George W. Bush, “President Bush, Prime Minister Sharon Discuss Middle East,” 7 February 2002. On-line. Last accessed, 20 June 2002. Available from <http://www.whitehouse.gov/news/releases/2002/02/print/20020207-15.html>. Moreover, could not global reach effectively emerge as a property of a network of

convince our indispensable international partners that we will not, as we did with infectious disease, “close the book” on terrorism should the terrorist plague cease to rage within our borders but continue to do so in theirs?

While we struggle with differences between types of terrorist groups, should we consider that the term “terrorist,” like cancer, is a catch-all term that says little about a prognosis or the treatments needed to counter specific terrorist cells, groups, and state sponsors? Do we, therefore, need a taxonomy of terror that clearly identifies the most lethal and widespread terror cells and differentiates among the lesser, albeit still terrorist, threats and the more traditional state sponsors? Moreover, who might be the terrorist “carrier” states—the states in which terrorists exist and possibly multiply but which show few or no ill effects from the terrorist presence? These states may be, like Saudi Arabia perhaps, with us and against the terrorists, but they harbor the infectious threat nonetheless and, in doing so, permit it to infect others. How do we treat them, and will they accept our prescriptions? If not, should they be quarantined or have treatment measures forcefully imposed?

Even within state borders, can a democratic people and its government remain resolute? Or will cycles of public health apathy and crisis response so evident in national policy also plague homeland security? Will terrorist activity and the national response, like disease awareness and prevention, wax and wane perpetually? Perhaps a human adversary will instill more determination—and hate—than a microbial one. But if not, then how best do we institutionalize protective measures so that future generations take them for granted, just as we do

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otherwise local groups? Also, given international travel, can we ever eliminate global reach of suicidal radicals? Finally, even if we could eliminate the global spread of specific terrorists groups, would not local groups retain the ability to threaten US interests outside the homeland?

many of the public health measures of earlier generations?<sup>6</sup> Will we waver in long-term effort yet steadfastly cling to traditional and ineffective interventionary “treatments”? On the other hand, how much folly is closing the book on traditional killers or threats to shift all of our emphasis to the new?

As these emerging threats increasingly assail our homeland, will we notice only the protection failures, taking for granted all the times that our protective systems worked without our being aware? How much collateral or “healthy tissue” damage will we accept as inevitable side effects of a successful protective response? Can we boost the protective systems of those countries that lack proper resources to protect themselves? Should we? Are we vulnerable to hypersensitivity reactions to foreigners, and might an overreaction to a misperceived threat damage our body politic? If so, how might we prevent such a response? Is it possible in our society that protectors could turn against the protected, a form of political autoimmune disease? How, in an era of fear, do we wield protective powers sufficient to counter terrorists without jeopardizing the stringent constitutional controls that prevent protective functions from going awry? If we loosen those controls, then how much and for how long? At what point is the treatment more burdensome than the disease?

Is international terrorism an acute ailment, like many infections, or is it likely to be a chronic societal ill? If the latter, what symptoms are endurable and acceptable? What long-term treatments, like raising the level of economic development in poverty-stricken areas to ward off disease and despair, thus lessening the sense of helplessness that incubates terrorism, are most cost-effective?<sup>7</sup> Perhaps we are only

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<sup>6</sup> For example: sewers, clean water, routine vaccination of infants, and mandatory rabies vaccines for pets.

<sup>7</sup> One unnamed Bush administration official reportedly called these weak states “petri dishes” for terrorist cells. David E. Sanger, “Bush to Formalize a Defense Policy of Hitting First,” *New York Times*, 17 June 2002.

witnessing a terrorist epidemic or pandemic, one that will run its course and subside. Yet, in this case, how will we know its over? And, can we ensure it does not reemerge, possibly in more deadly form?

Here the cancer metaphor may be especially apt: even in the absence of symptoms, will we truly know that we have eradicated all of the metastasized terrorist cells? Can we ever be sure? Might our remission from fear be only temporary? Whether short or long, probably we can only know this war is over in retrospect. Ultimately, will we begin assessing terrorist “cures” as we do cancer—in terms of five-year incident-free periods? If “a *permanent* victory over international terrorism is unlikely,” then how do we justify normally acceptable “war-time” restrictions on civil liberties?<sup>8</sup> At what point do we restore the liberties lost? It is a vicious cycle, to be sure. The liberties that give disease and terrorism such easy entrance to the body politic are among our most cherished. Again, at what point is the treatment less tolerable than the disease?

Few of these concerns are new; the disease metaphors may thus add little insight for experienced policy makers.<sup>9</sup> The metaphors are not, however, short cuts to solutions—they are merely tools for education and exploration. They illustrate important facets of the nature of our current adversary and the nature of the war. As such, disease imagery can frame the core “war” issues in a comprehensive and easily understandable way: immunity as protection; public health as prevention; medical treatment as intervention. While these metaphors suggest immediate organizational and policy responses to terrorism, they are not definitive or narrowly prescriptive.

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<sup>8</sup> Haass, 21 September 2001.

<sup>9</sup> People invoke, for instance, the Japanese internment, the excesses of the Hoover FBI, and the Red scare to illustrate the potential threats to human rights posed by a war on terror. Some military officers, moreover, note that the problem of identifying unlawful combatants hidden in a civilian population is—as with the war on terror—the core issue in combating insurgencies, conflicts which may simmer for decades.

Rice, Haass, and Wolfowitz correctly applied aspects of these metaphors to enrich public understanding of the tasks ahead in this new war—a potentially long struggle, one often unseen, one without clear terms of victory. The disease metaphors clearly resonate with many leaders; perhaps they will with the public as well. If so, they can fortify resolve and summon long-term support, a critical base for whatever treatment strategy might be selected. In the end, perhaps this new language can help redefine our expectations of war. Perhaps that is enough.

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### **General Information**

The US National Library of Medicine's (NLM) Medline Plus Health Information website provides numerous links to excellent public education resources. One can supplement these materials with information from the World Health Organization (WHO) and the US Centers for Disease Control and Prevention (CDC).

**For immune system information**, see <http://www.nlm.nih.gov/medlineplus/immunesystemanddisorders.html>.

**For infectious disease information**, see NLM resources at <http://www.nlm.nih.gov/medlineplus/infectiousdiseasesgeneral.html>; WHO materials at <http://www.who.int/inf-fs/en/index.html>; and CDC publications at <http://www.cdc.gov/health/>.

**For cancer-related materials**, see the NLM's site at <http://www.nlm.nih.gov/medlineplus/cancergeneral.html>. Also, see the National Cancer Institute's "Science Behind the News" at <http://newscenter.cancer.gov/sciencebehind>.