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BIOLOGICAL WARFARE MODEL 1967

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UNTIL last year no great strategic surprise seemed attainable in warfare by the sole resort to biological operations. The defense planner could rely on a number of distinct advantages, including one of knowing that his opponent was probably fettered by public opinion. While traits of this pattern remain, an entirely new situation is rapidly developing. It threatens to burden military planning with a new type of decision, acrid and ponderous.

Any trace of surprise adhering to this kind of warfare would seemingly be erased through the wide and swift dissemination of new knowledge in the field of microbiology. Well-equipped laboratories in the East and West work with identical or closely related problems. The trail-blazing cryptanalysis of the genetic code was inaugurated by an American report to an international congress in Moscow.

The very identification of microbiological problems with those of fundamental and intensely studied life processes would prevent discoveries within this field from being forged into "secret" weapons. Factors of decisive surprise inhere, however, in the swift buildup made possible by modern microbial engineering and in emerging developments in basic research.

Biological operations—defined as the employment of biological agents to produce casualties in man or animals and damage to plants or materiel—have long been evaluated from every angle excepting that of experience. While the chronicle of war and subversion knows of attempts to transmit infections to troops, their mounts, and food supplies, such episodes have less to tell about tomorrow's biological warfare than have the limited epidemics and health hazards met under field conditions. Today, countermeasures against biological attacks rest heavily upon the latter types of experience. Interpretation of basic research supplies data of vital importance to defense planning.

Microbes Called Up

Agents proposed for biological operations include bacteria such as the anthrax bacillus and the cholera vibrio, rickettsiae such as those of typhus and Q fever, and viruses exemplified by the causative agents of yellow fever and dengue. These and several other microbes can be used to cause casualties by infection. Some bacteria produce toxins that can be used as such. Botulin, the toxin of the bacillus Clostridium botulinum, can be prepared in crystalline form which kills in doses of less than a millionth of a gram. In general, living agents appear to have wider application owing to their capacity of self-replication.

This last property allows the epidemic propagation of biological agents and meets the essential requirement of mass production. With three generations an hour one single bacterium could, theoretically, in 24 hours produce thousands of tons of bacteria. Yet one gram of dry embryo mass with cultured Q fever agent contains about one billion infection doses.

Huge masses of microbes are already handled in a multitude of industrial procedures. Clostridium acetobutylicum—renowned in World War I as the saver of the British cordite manufacture by supplying acetone—became important as a producer of butanol. For this purpose, fermentors measuring up to 500,000 gallons are used to handle this bacillus. Rickettsiae and viruses are also at hand now in great quantities since they are used to prepare vaccines.

The effectiveness of biological agents may be limited by natural or man-made factors. The requirement of host susceptibility is fulfilled by the tetanus or lockjaw bacillus when directed against civilians but not against immunized troops. In certain geographical regions, endemics and silent infections produce a high immunity level against yellow fever, and the same limiting factor operates against several other biological agents. Protective and therapeutic doses of antibiotics decrease the casualty rate in attacks with bacteria and rickettsiae. It is here, with the aim of breaking through individual defense, that innovations have produced new biological agents and may produce entirely new situations of strategic vulnerability.

Reeducate Agents

Biological agents can be reeducated. Vladimir A. Engelhardt of the Soviet Academy of Science has predicted the reeducation of pathogenic microbes so that in the future it would be possible to bring about artificial changes rendering them harmless. Lasting artificial changes of microbes in the opposite direction have, in fact, been produced in Soviet and other laboratories where increased resistance to antibiotics serves to signal changes in bacterial deoxyribonucleic acid (DNA), the primary carrier of genetic information.

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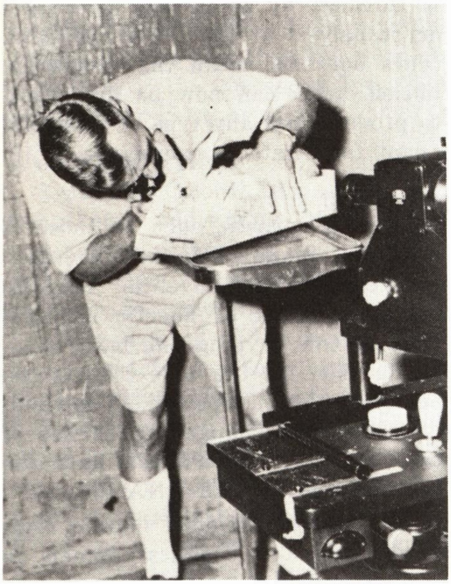
One by one spontaneous changes of the smallest components in the DNA molecule are rare; taken together they are numerous in the enormous bacterial populations represented by laboratory cultures. With suitable techniques, mutant microbes can be detected and multiplied. It is also possible greatly to increase the rate of nondirected mutations by exposing microbes to X-rays, gamma rays, or chemical agents such as mustard-type gases, nitrous acid, ethylene imines, and various purines. By such methods microbes have been produced for special purposes, including industrial procedures of great economic importance.



US Army

The rabbit played an important part in research on the DNA molecule

Directed mutations have already been produced with resort to compounds similar to the bases holding together the two strains of the DNA molecule. Here, a careful timing is needed since the primary genetic information carried by the base arrangement can be changed only in the moment when the tiny target segment replicates. Once this qualified laboratory feat has been performed, the changed microbe can be multiplied in any kitchen.

Today, the potential versatility of biological agents cannot be realized with the sole resort to artificial mutations. Special target systems require modifications of microbes which are now thought of as attainable by transfer of genetic information from one microbial strain to another. These combine high virulence with resistance to antibiotics and other characteristics specified for a number of objectives.

Transfer Procedures

The material carrying such transferred information is DNA. One procedure of transfer is conjugation, a temporary union of two living bacteria occurring, to cite an instance, in the cholera vibrio. A second procedure, termed transformation, integrates with the DNA of one bacterium DNA extracted from a related donor microbe. In transduction, a third form of transfer of DNA from one microbe to another, viruses attacking bacteria inoculate a minute segment of genetic material from one bacterium into another.

To improve crop plants or livestock, the breeder combines genes of sexually reproducing organisms. By conjugation, transduction, and transformation, bacterial genes can now be combined to produce organisms with required operational characteristics.

At the present time, only very simple melodies can be played upon the keyboard represented by the array of genetic information in the long DNA molecule of microbes. Minute parts of the encrypted DNA messages of related microbes are puzzled together, and changes in microbial prowess are observed and used when they take the wanted direction. Work of this type is necessary to solve basic problems, but it is also immensely time-consuming.

It has, however, become possible to recognize microbes the genes of which can be combined by transformation. Normally, the DNA molecule forms a long double coil. If it is denatured by heating, the strands of this double coil become separated. Double coils of DNA can then be reconstituted by slow cooling. The bases holding the two strands together, adenine, guanine, cytosine, and thymine, can be arranged in different patterns. If these patterns of two different DNA molecules are similar, then single strands from each of them can form hybrid molecules. To be specific, DNA from coli bacilli has been combined to hybrid molecules with DNA from dysentery bacilli.

Recent Breakthrough

While such research—explaining important properties of transforming DNA—prepared the terrain for further advance, a series of fundamental discoveries revealed how the primary genetic message was encrypted in the DNA base sequence, thus preparing the way for a breakthrough.

In the life of the independently living cell and in that of the composite organism, highly active products, often with catalytic functions, are formed by arrangement of 20 amino acids in chains of different patterns. These patterns are the plain text with 20 letters. Now, code triplets in ribonucleic acid (RNA) and DNA have been found for each of these 20 amino acids constituting the letters of the plain text alphabet.

When the first substantial progress in the cryptanalysis of the genetic code became widely known in 1962 and 1963—much of it reported from M. W. Nirenberg's laboratory in Bethesda, Maryland and Severo Ochoa's in New York—some extrapolations put before the public were safely in advance of facts. The successful cryptanalysis of the DNA and RNA codes does not mean that microbian nucleic acids can now be programed to produce just any type of biological agent for strategic operations.

Sole Carrier

In some viruses, such as those of influenza, mumps, canine distemper, measles, and poliomyelitis, RNA is the sole carrier of genetic information. In this cryptogram, bases similar to those of the code triplets can be artificially incorporated. The result is inheritably changed properties of the virus. Such experiments have also been successful with DNA viruses.

In addition, artificial nucleic acids served as false chemical signals in the cryptanalysis. By interpreting their effect, the analysts traced the natural code triplets. But the intimate knowledge about the amino acid chains produced by RNA and, ultimately, in the case of some viruses, directly determined by DNA, is still fragmentary. The same is true about the relationship between nucleic acids and the ability of micro-organisms to cause disease. Much is known, but not enough to program the nucleic acids for specific tasks.

Now, avenues of swift approach have suddenly been opened. It has been known for some time that each amino acid has to be carried to the conveyor belt of RNA by its own specific, minor RNA molecule. In March 1965 Robert W. Holley and his coworkers reported the analysis of the complete nucleic acid sequence of one such transfer RNA molecule, that for the amino acid alanine. The report ended with the forecast that biologically active nucleic acids will be synthesized.

As pointed out by Tracy M. Sonneborn of Indiana University, this determination of a whole RNA molecule reveals for the first time the complete structure of the corresponding DNA segment, or gene, or cistron.

Psychological Problems

Years ago Colonel Dan Crozier and coworkers, addressing the medical community, pointed to the psychological problems resulting from fear of exposure to something new that cannot be registered by the senses. There is little ground now for alarming speculations about immediate threats from unknown weapon systems. However, there is less ground still for unconcern with a very fluid situation. It may be feasible to produce artificial RNA molecules and to incorporate them with viral RNA, and it may take 18 months or more to produce entirely new viruses with characteristics desired for certain military targets.

Suppose that power A needs time to meet a rapidly materializing threat from neighbor B and attacks B's joint chiefs of staff. The ventilation system of the staff building invites an attack with aerosolborne biological agents and a janitor is ready with an ordinary spray gun. He can use botulin for the complete extermination of all personnel. Within hours of exposure the victims will have visual disturbances and speech difficulties followed by respiratory paralysis and cardiac arrest.

A's planners might reject this plan as it would imply the swift replacement of their opposite numbers with men of predictable disposition and less predictable patterns of action. They could, instead, send the janitor a stock culture of small bacilli causing brucellosis, concealed behind a postage stamp. Messes and cafeterias would serve to distribute microbes

Embassy of Pakistan

The agents of yellow fever and a number of encephalitides can be spread from the air

with food and beverages. Aerosol propagation would be a possible alternative.

The incubation period would vary from days to weeks. A disease with an insidious onset would develop with some fever—rising in the afternoon —malaise, irritability, and night sweat. A series of symptoms often described as psychoneurotic would characterize the long-term course. While many affected persons would be palpably ill, others would ascribe their symptoms to overwork and mounting tensions. Periods of deceptive recovery would make top strategists reluctant to adorn the sick roll.

By executing this plan, A could deny any responsibility for the staff endemic. He would find existing microbes and methods of delivery, not mentioned here, wholly adequate for this objective. Modified microbes for the laming of operational planning and execution would probably release or produce weak neurotoxins, blunting judgment and power of decision while provoking a mild euphoria, manifest in a smug reliance of the victim in his mental prowess.

Airborne Dissemination

A second type of target could be exemplified by sealing off broad jungle areas from ground operations. With existent spray equipment the agents of yellow fever and a number of arthropodborne encephalitides can be spread from the air. When inhaled, they would cause a high attack rate and a short incubation time. Victims would usually be severely ill with fever, chills, and headache, followed in yellow fever by lesions in the brain accompanied by confusion and later, in some cases, by lasting blindness, epilepsy, or paralysis.

In all these diseases, mild and inconspicuous cases occur. In the encephalitides, the peacetime attack rate is low. The names of the encephalitides imply restriction to certain geographic regions: Venezuelan equine encephalitis, Saint Louis encephalitis, Japanese encephalitis, Murray encephalitis, Czechoslovakian encephalitis, and Kyasanur Forest disease. After an airborne dissemination, the maintenance of endemics will depend upon troops, civilians, mammals, and birds serving as reservoirs for infection. Local and especially supplied vectors such as mosquitoes, ticks, and mites will carry the infectious agents from host to host.

For such targets new agents would aim at overcoming local immunity and adapting viruses to local vectors. Viruses as well as bacteria may combine to form hybrid molecules, exemplified by the recently observed tumor-producing DNA virus with antigenic properties of adenovirus type 7, the latter cultivated to produce vaccine. In some situations it would not be necessary to resort to radically new viruses with a high attack rate in order to produce a psychological effect marking certain regions as unsuitable for long-term stay and personnel passing through these regions as carriers of dangerous contamination.

Industrial Districts

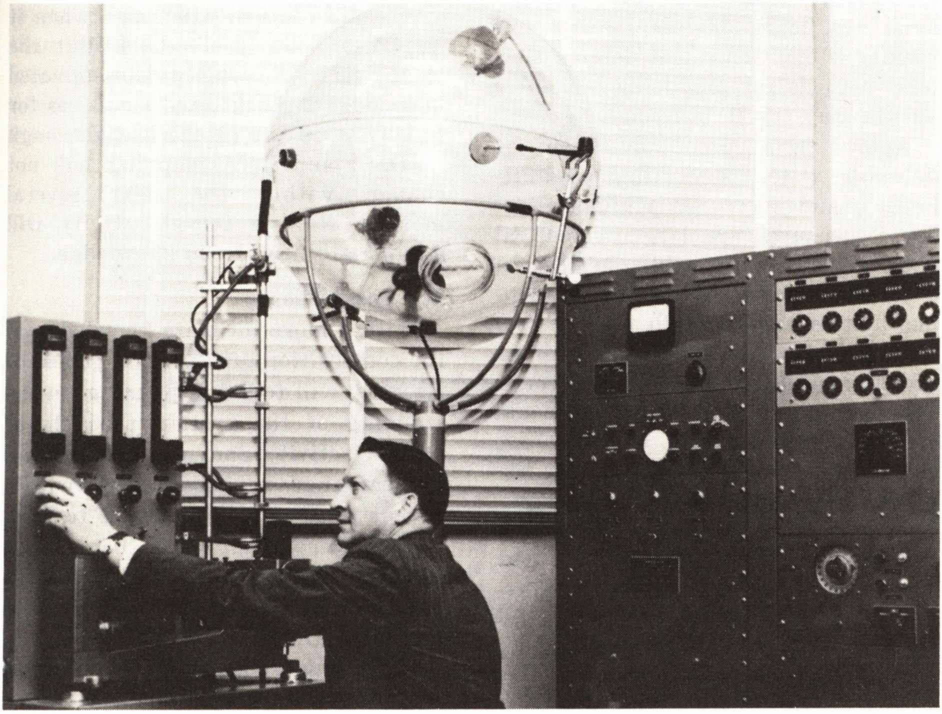
A third type of target for biological operations is represented by key manufacturing districts. Mass infection causing prolonged sickness would disintegrate the enemy's warmaking capacity and raise demands for medical and sanitary personnel which the armed forces would have to forego.

Clandestine operations provoking concurrent endemics and escalating epidemics could use food and drinking water to spread the infectious agents. Among them, the viruses of hepatitis or epidemic jaundice cause long-lasting and incapacitating illness. The hardy agent of Q fever produces influenza-like symptoms and extensive changes in the lungs.

Adequate biological agents for the continuous paralyzing of industrial districts exist, and they could conceivably be improved in resistance to treatment, virulence, and invasiveness.

For the fourth type of operations —main attacks against troop concentrations and maintenance areas, population centers, and debarkation harbors—a likely method of delivery would be dissemination of the agent or agents by aerosols. As experiments have shown, a fishing craft can, from far offshore, wrap a big city or coastal area comprising thousands of square kilometers in a fine-particle, invisible aerosol cloud loaded with any of the infective agents of tularemia, equine encephalomyelitis, plague, and anthrax.

Anthrax spores, disseminated by aerosol with the aid of missiles, bombs, airplanes, or submarines, would cause a severe form of pneumonia, now rare, once known as "woolsorter's disease." After an attack of this type, millions of people become ill simultaneously. If complete surprise is attained, the fatality rate will approach the 99 percent observed in untreated cases. A complete breakdown of military and civil defense and a heavy domestic pressure upon what might remain of authority could be attained within 48 to 96 hours of an attack. New developments might contract the interval within which victims take sick and increase drug resistance. An extremely high casualty rate and a practically simultaneous onset will relieve the invader from concern with secondary epidemics.



US Army

Swift detection of biological agents in airborne dust and moisture particles by devices such as this germ counter offers some defense against biological attack

Defense against biological warfare is also undergoing intense study. The swift detection of biological agents has been facilitated by the use of fluorescent antibodies. Conventional sampling and culture techniques—supplied in given instances with animal tests to identify micro-organisms and their toxic products—remain useful especially against operations of the second and third types described earlier.

Mass Immunization

Mass immunization against a wide variety of biological agents is effective today, if only partially so. Artificial and more or less natural immunity is one element of defense that new methods for producing biological agents may try to overcome.

Apart from decontamination of drinking water, stockpiling of antibiotics, and increased vigilance, defense measures are largely identical with principles of public health. In a phase of fervid, scientific development, it is easy enough to maintain that a major breakthrough such as the decrypting of the complete message of alanine transfer RNA could well have been foreseen. In retrospect, this is true for a series of the remarkable achievements of modern microbiology. The likelihood of the development and employment of new agents for biological operations remains, in spite of its apparent futility, a first-range countermeasure against surprise attacks.

It could be added that the planners' sense of responsibility would prevent any use of the forthcoming techniques for military purposes. Weapon systems threatening mankind with extermination will not be resorted to by nations with realistic goals and ample means to defend themselves. However, this factor becomes less easy to evaluate when it is remembered that the detailed map of the new scientific territory is now in the hands of performers not thought of as main protagonists on the present scene of international tension.

One chilling influence upon offensive planning would be exerted by the knowledge that the prospective victim is well prepared to meet the threat and answer in kind. No great industrial nation would be a likely target for biological operations in the foreseeable future.

It is a moot question how far the foreseeable future will reach when it is, indeed, not predictable. But the basic fact of widely disseminated knowledge and scattered resources for following up the recent breakthrough in DNA and RNA mapping will not change within the next several months. Now, a fervid activity will accumulate new, basic knowledge.

New Possibilities

With a more intimate knowledge of the composition of microbial genes, or cistrons, will follow a ripening understanding of the protein products of cistron activity and new possibilities to rearrange base sequences within the cistrons. It is not possible to forecast the amount of work that will be absorbed in attempts to interpret the offensive properties of microbes in terms of DNA and RNA sequences. Although microbes may seem simple enough compared to higher organisms, they have complex patterns of metabolism and some surprises of their own when cornered in the laboratory.

It is, then, not possible to predict how many months or years it will take to develop radically new biological agents. The time lapse between the emergence of such agents and the possible employment of weapons loaded with these agents can, however, be estimated.

Into this calculation goes the fact that quantities of any malignantly reeducated microbe will be required. Although one single, old-fashioned plague bacillus inhaled is sufficient to kill its victim, considerable quantities are needed to safeguard mass destruction within the target area.

Here, modern industrial methods of continuous operation of fermentors advance into the picture. Such methods were not available to the belligerent nation that produced little more than 2,000 pounds of cholera vibrios a month during World War II. Today, a single plant, operating with continuously fed substrate and a continuous harvest of microbes, can produce this quantity in less than a day. Provided that other equipment for this weapon system can still be used when the new biological agent has been developed, effectively concealed buildup is a question of days only. Whatever the surprise factor may amount to, the sudden revelation of such buildup would constitute an almost unparalleled argument in a strategic dialogue between contesting powers.

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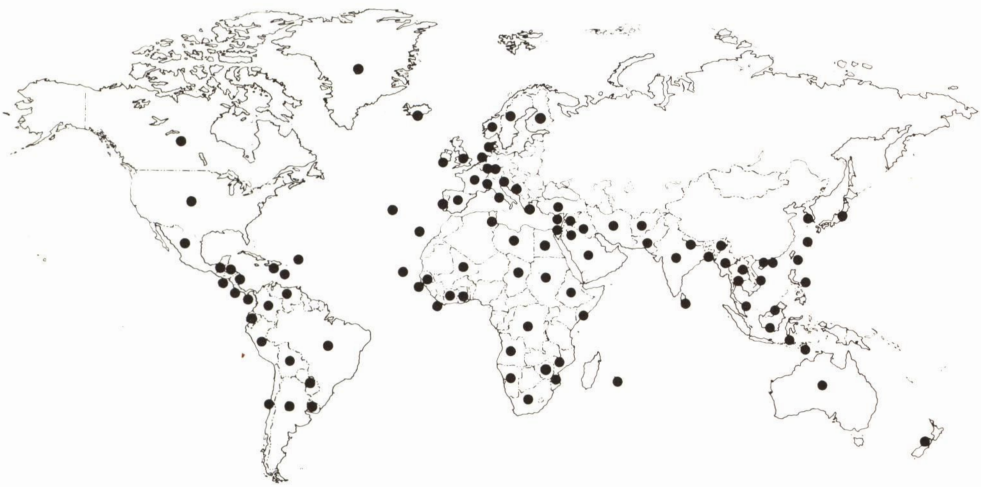

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