For example, in 1972, the USDA overestimated the likely size of the Soviet wheat crop; as a result, the United States allowed the Soviet Union, which in fact was desperately in need of imports, to buy up U.S. grain at now-notoriously low prices. Bad weather reduced the Canadian wheat crop in 1970–71 and in 1974–75, each time increasing the demand for U.S. crop surpluses. In 1974, drought reduced the U.S. winter wheat crop and record-breaking cold reduced the supply of corn and sorghum.

Since taking office as Secretary of Agriculture in 1971, Earl Butz has been characterized as following policies of minimal interference in private food trade. He therefore allowed the sale of U.S. grain stocks and has refused to consider renewed government stockpiling on the grounds that this would constitute interference in the market. Similarly, it has been charged that the USDA's steady crop forecasts minimize the confusion in commodity trading. If the government announced sudden changes, according to one official, the "pits" of the exchanges where commodities are traded daily "would go crazy." Finally, Butz's critics argue, by predicting that there will be plenty of food for all, the department sidesteps the sensitive issue of stockpiling.

There has never been any evidence that USDA's crop forecast estimates are manipulated for these political goals; on the contrary, Kirkbride and his staff go out of their way to explain that they are isolated (and literally "locked up" in the USDA basement with disconnected telephones) when the estimates are compiled. However, it is clear that the USDA system of crop forecasting produces results which are supportive of overall USDA policy goals.

If climatic variability continues, or, as some climatologists say, if a cooling trend continues, the main grain-growing regions affected will be those in Canada and the northernmost grain-growing provinces of the Soviet Union. This fact has concerned security agencies for some time; for example, it is discussed in two reports written by the CIA in 1974 and released publicly last year.† One problem which has been mentioned is whether the Soviet Union would become "more militant" in its quest for food if climatic change diminished the productivity of certain key provinces.

A related security issue is the dependence of less developed countries on North American grain surpluses. Some of the unusual weather events of the 1970's have included a 1972 delay in the onset of the monsoon in grain-growing provinces of India. In 1974, bad weather diminished Indian corn, barley, rye, and oats crops by 15 percent; wheat harvests declined 10 percent. It is obvious that accurate grain forecasts—especially as drought and famine situations develop elsewhere in the world—would help both traders and the government decide how to allocate the much sought-after American crops.

Some solution to the argument between the climatologists and USDA, and to the concerns of security agencies, is being sought in a crash, 1-year study now under way at the National Defense University by a select group of meteorologists and agricultural economists. William Gasser, on leave from the USDA to work on the project, explains that the group will first try to resolve the debates within the climatology community as to the likelihood of increased weather variability. It will try to get the scientists to assign probabilities that unusual events will occur. "The scientists have made general statements about what's going to happen to the climate," says Gasser. "But they are useless to the policy-maker unless he has a number, a probability, that the event will occur." The study will examine alternative policies the government could follow, from revising USDA crop forecast methods to revamping the sponsorship and focus of climatological research.

In the internal government debate over the future of weather and USDA's food policies, a number of scientists and scientific committees have concluded that climatology is due for a massive infusion of funds similar to that given to meteorology in the 1950's. "Climatology has been the Cinderella of meteorology," says one prominent scientist, who, like others, advocates a major new thrust, more money for graduate students, and more projects for government research contract centers.

But, in claiming that yield forecasts can be made better, the scientists have leaped into issues involving millions of dollars in trade, the privateness of private industry, and sensitive aspects of U.S. foreign policy. It would be sad, and perhaps irresponsible, if the only solution they propose is that they be given more money.—DEBORAH SHAPLEY

†The most complete of the two reports is *Potential Implications of Trends in World Population, Food Production, and Climate*. Central Intelligence Agency, Directorate of Intelligence, Office of Political Research. Document Expediting Project, Exchange and Gift Division, Library of Congress, Washington, D.C. 20540.

Swine Flu Vaccine: A Component Is Missing

The vaccines that will be used in the swine flu immunization campaign this fall will be largely ineffective in stimulating one of the body's traditional defense mechanisms against the ravages of the disease.

The clinical trials conducted last spring revealed that, while the vaccines seem relatively successful in stimulating the body's first line of defense against swine flu, they largely lack an active component that would trigger the body's second line of defense. This component has apparently been inactivated somewhere in the process of manufacturing the vaccines.

Virtually all experts agree that the vaccines would be more effective if they contained components that would activate both defense mechanisms. But there is some uncertainty as to whether the lack of the secondary component is a significant failing. Some leading scientists involved in the mass vaccination campaign told *Science* that the diminution in effectiveness of the vaccine will be relatively minor. But a few other investigators are skeptical. "What else can they say?" commented one top researcher for a company that is manufacturing the vaccine. "We've got 150 million doses of vaccine without [the secondary component]. That has to be their stand."

The ingredient that is largely ineffective is neuraminidase, one of two key proteins found on the surface of influenza viruses. These proteins are tools which enable the natural virus to pene-

trate and spread through the body. They are also the key to the effectiveness of the vaccine because they stimulate the production of antibodies. An individual who receives a vaccine containing the virus develops antibodies that are able to combine with and neutralize the surface proteins on a natural virus which later attacks. It is largely by blocking the action of the two surface proteins that the body protects itself against influenza.

The most important of these proteins, known as hemagglutinin, is chiefly responsible for the infectivity of the virus. It enables the virus to attach itself to cells within the body so that the virus can invade the cells, take over their reproductive machinery, and begin to replicate itself. The role of the neuraminidase is less well defined, but the consensus is that it assists the replication process, perhaps by facilitating the release of progeny virus particles from infected cells so that they can attack other cells or by performing other functions.

Most experts agree that an ideal vaccine against swine flu should probably contain both hemagglutinin and neuraminidase. The hemagglutinin would stimulate the formation of antibodies that would neutralize the hemagglutinin on a swine flu virus that might later invade the body, thereby making it impossible for the virus to penetrate any cells. The neuraminidase, meanwhile, would stimulate antibodies that would interfere with the virus's ability to multiply and spread through the body, should the first line of defense be breached.

There is some evidence—fragmentary and controversial—that very high levels of antibody to neuraminidase can actually prevent infection. But whatever role such antibodies may play in prevention, it is generally agreed that they can reduce the severity of any infection that occurs. The antibodies to neuraminidase also appear to diminish the likelihood that infected individuals will spread the virus to others.

Unfortunately, for reasons that are not clearly understood, the vaccines that are being produced for the swine flu campaign this year do not have an effective neuraminidase component. This was made known in a little-noticed report presented on 21 June at a meeting held at the National Institutes of Health to discuss the results of clinical trials of the swine flu vaccines. Alan P. Kendal, of the federal Center for Disease Control, reported that "quite unpredictably" most of the vaccines tested showed no significant neuraminidase activity when subjected to an enzyme assay. They also produced only small or insignificant increases in antibodies to neuraminidase in volunteers who received the vaccines during clinical trials.

What happened to the neuraminidase component remains something of a mystery. Kendal noted that tests of the seed strains used by the manufacturers showed "readily detectable levels of neuraminidase activity," which led him to assume that the lack of such activity in the final vaccine product "is due to some inactivation during production." He could find no evidence indicating at what stage of manufacturing the problem occurred or "how it might be prevented under real production conditions." In a recent telephone interview, Kendal said the problem may be caused primarily by characteristics of the swine flu virus which render its neuraminidase proteins unstable and difficult to work with.

Calcium Might Help

At least one prominent flu investigator—Robert G. Webster, of St. Jude Children's Research Hospital, Memphis, Tennessee—believes that it would have been possible to retain the neuraminidase activity simply by adding calcium ions during the purification process of vaccine manufacture. He claims good results using calcium in his own laboratory; but some specialists question whether such results would be applicable when extrapolated to a large-scale manufacturing process. At any rate, by the time the problem became apparent, the swine flu campaign had gained such momentum and the manufacturers had already produced so much vaccine that little thought was given to tinkering with the production process.

How significant the lack of a neuraminidase component might be is uncertain. There is virtually nothing in the scientific literature that indicates what added protection might be provided by neuraminidase antibodies when hemagglutinin antibodies—the first line of defense—are already present. The most vociferous critic of influenza vaccines—J. Anthony Morris, a former laboratory head at the federal Bureau of Biologics—considers the lack of neuraminidase "a defect" in the way the vaccines are put together. "Nature is seldom superfluous," he says. "You have a second line of defense for good reason. No one can be certain the first line will work." But Morris is so dubious about the effectiveness of influenza vaccines that he doesn't think they would work even if they had an active neuraminidase component.

Kendal, of the CDC, told *Science* he is "not terribly concerned" about the vaccines' failure to produce antibodies against neuraminidase because he believes such antibodies would offer "very minor additional protection" to that provided by the hemagglutinin antibodies. Two other leading flu scientists, who stressed that they were speculating in the absence of hard data, suggested that lack of a neuraminidase component might diminish the protective effect of a typical flu shot by 10 to 20 percent from what it might otherwise have been—a loss that they considered unfortunate but not catastrophic. For individuals whose first line of defense proves sufficient, the loss would not even be noticed. For those whose first line proves porous, the lack of back-up protection could allow detectable illness.

Harry Meyer, director of the Bureau of Biologics, the agency that regulates vaccines, sees no evidence that "the vaccines will be inferior vaccines" simply because the neuraminidase is relatively inactive. He considers neuraminidase a matter of interest to researchers, but feels that the data are too inconclusive to warrant causing "massive changes" in the production process. Still, as Edwin D. Kilbourne, the microbiologist who produced the seed strain used in manufacturing the vaccines, observes, "It would obviously be desirable to have a vaccine that raised the antibody to both" hemagglutinin and neuraminidase.

In an ironic footnote to the affair, the neuraminidase problem has cast new light on a much-publicized manufacturing error by Parke, Davis & Co., one of the four manufacturers of swine flu vaccine. A few months ago it was revealed that Parke-Davis had made some 2 million doses of the wrong vaccine. For reasons never fully explained, the vaccine contained a hemagglutinin component more like an older swine flu strain than like the strain found at Fort Dix early this year—the strain that is the target of the current mass immunization campaign. But, oddly enough, that "wrong" vaccine does exhibit some neuraminidase activity. And its hemagglutinin—while it is not precisely the hemagglutinin desired—does appear to stimulate antibodies that would be effective to some degree against the Fort Dix strain. Thus it is always possible, according to some flu experts, that the total protection provided by the "wrong" vaccine, which at least has two active components, might be as great or greater than the total protection offered by the "right" vaccines, which have only one active component. Such are the imponderables which make life difficult for the influenza experts.

—PHILIP M. BOFFEY