Biological Innovation and American Agricultural Development

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The Problem:
In most areas of economic activity technological solutions last forever. A new idea, method, or type of machinery only becomes obsolete when it is replaced through the competitive process by an even more productive innovation. But the old idea is neither destroyed nor lost; it is just no longer efficient. In many instances the new build on the old, giving rise to the cumulative nature of technological development. In addition, for most sectors innovations tend to be highly footloose—an idea or a machine developed in one country is apt to work equally well in a wide variety of environments. Agricultural is different. Human intervention into biological processes predictably produces natural reactions in the form of pests and pathogens that inevitably erode the productivity and of past innovations. Farmers have long understood the Red Queen’s dictum: they have to run fast just to stay in one spot. Moreover, unlike many mechanical or organizational innovations, biological technologies must be fine tuned and harmonized to the specific climatic and soil conditions of a given local, and maybe a given plot of land. This insight becomes extremely important when the primary challenge of nineteenth century American development was nothing less than the settling of an entire continent.

The Literature:
The literature analyzing American agriculture development in the nineteenth and early twentieth centuries has largely ignored the above problems and concentrated on mechanization to the virtual exclusion of biological innovations. Willard Cochran’s statement that mechanization “was the principal, almost the exclusive, form of farm technological advance” between 1820 and 1920 effectively summarizes the received wisdom. Numerous other prominent scholars have argued that American farmers were not even “interested” in biological innovations until land became scarcer. In this literature important biological developments only started with the spread of hybrid corn and synthetic fertilizers in the inter-war decades.

Themes:
Over the 150 years before 1940 biological innovations were absolutely essential for the development of American agriculture, rivaling or exceeding the importance of mechanical innovations for almost all crops and animals. Our analysis intertwines two dynamic processes: combating the “Red Queen” effect and adapting agriculture to an unknown and hostile environment. Biological innovations took the form of inventing new cultural methods, introducing new crops, changing crop mixes, and limiting the damage done by pests and pathogens, and finding crops and animals that could prosper in the myriad geoclimatic niches as the line of settlement pushed ever westward. These innovations had an enormous impact on both land and labor productivity and in the case of animal products had dramatic spillover effects on human health. As one example, steps taken to improve milk quality were saving well over 25,000 lives a year in the United States by 1940. Based on what was written in the farm press and how farmers invested their time and money, biological innovations swamped the importance of mechanical innovations. Many biological and land-building innovations (be it the control of diseases and pests, the restructuring of the cotton industry, the draining of
millions of acres of swamplands, or large-scale irrigation projects) involved collective action problems that were generally absent in the story of mechanical innovation. This often led to government intervention to overcome free rider problems and generate basic and applied research. Even though these investments have generally been overlooked, they have generated extraordinarily high rates of return.

Although parts of our story appear in scattered specialized sources, we will tie the development of the various agricultural sectors into a unified whole built on a common conceptual framework. We will offer macro perspectives such as estimating the productivity effects of biological innovations, detailing the effects on human health, and noting how our findings suggest new insights for modeling agricultural development. We will offer international comparisons and point to how our findings suggest a wholesale rethinking of the development of medieval and early modern European agriculture.