Roman history, and his own observations of contemporary Italian politics, Machiavelli set out on a quest to determine the optimum form of government for a people wishing to maintain their liberty and prosperity. Perhaps what makes him most unique in this quest is his envisionment of man's political interaction as a physical system, where structure can be just as important as substance.

> "...one should organize the laws in such a way that they force upon the city those necessities which the location does not impose; and one should imitate the wise men who have lived in the most beautiful an fertile of lands, lands more apt to produce idle men unfit for any vigorous activity; in order to avoid the harm which the pleasant nature of the land might have caused because of idleness, they constrained their soldiers to undergo such training and exercise that better soldiers are produced there than in lands which are naturally harsh and barren." (*Discourses*, 174)

With the Discourses, Machiavelli ushers in the age of the social engineer. Politics is very complex, yet there are some generalities which can be deduced by studying the history of various peoples, and the application of these principals can bear much fruit.

> "Anyone who studies present and ancient affairs will easily see how in all cities and all peoples there still exist, and have always existed, the same desires and passions. Thus, it is an easy matter for him who carefully examines past events to foresee future events in a republic and to apply the remedies employed by ancients, or, if old remedies cannot be found, to devise new ones based upon the similarity of events. But since these matters are neglected or not understood by those who read, or, if understood, remain unknown to those who govern, the result is that the same problems always exist in every era." (*Discourses*, 252)

Machiavelli does not, however, claim to have reduced politics to a science. In The Prince he admits that no matter how well prepared the politician is, success in worldly endeavors is dependent on both fortune and skill. (*The Prince*, 96) However, he demonstrates that he understands the science of probability throughout his writings, and his ideas are facinating because they so often have a mathematical rationale. His analysis of the duel between the three Roman Horatii and three Alban Curiatii offers a case in point. This incident occurred as the armies of Rome and Alba were massed opposite each other and preparing to battle. In order to avoid enormous bloodshed, the two sides agreed that the outcome of war would instead be decided by a duel between three warriors from each side. Concerning this situation, Machiavelli points out that it is very unwise to risk everything on only a portion of ones forces. By fighting a duel such as this one, each side gave up any systematic advantage they might have possessed. While it is difficult to predict the outcome of a struggle between a few individuals (after the duel only one Roman remained, of the six participants), much more certainty can be placed on the advantage of numbers, equipment, training, location, morale, etc. All of these were nullified by the decision to duel. Machiavelli is concerned with this issue because his desire is to improve the political *system*. He recognizes the uncertainty of micro-phenomena, and seeks out practices

which result in greater holistic well-being.

In one sense, Machiavelli is the political alter ego of the economist Adam Smith. Smith's Wealth of Nations put capitalism on a solid theoretical footing, establishing the science of economics. In it, Smith argues that in an economic system properly consitituted, the centrifugal tendencies of the population can be harnessed to provide for the best interests of all. "We look not to the good will of the butcher, baker, and candlestick maker..." In effect, Machiavelli said the same thing two hundred years earlier in the Discourses. It is the system of law and government which insures the healthy functioning of the political system, not the virtue of the individual. Until this point, it had been accepted that the desired goal was a good political system, and this was to be attained through the virtue of the individual. Machiavelli ingeniously reversed this argument, claiming that while virtue might insure the proper functioning of the political system, a good political system was necessary in order to insure the maintenance of civic virtue (an Aristotelian idea with a twist). Thus, the problem now had to be dealt with in a systematic fashion.

1.2 System Dynamics

System dynamics is a modeling methodology concerned with the complexities of non-linear behavior which are present in most social systems. It has its origins at MIT during the late 1950's, developed by Jay W. Forrester, an electrical engineer concerned with applying the power of modern computing techniques and cybernetic theory to the pressing social issues of the day. System dynamics differs from more conventional modeling methodologies in the scope of the systems it attempts to describe. Most engineering analyses start with some sort of linear or analytical "first-cut" description of the process. For many physical systems, this initial "back-of-the-envelope" calculation yields reasonably accurate results. The engineer can then either use this preliminary data as is or he can proceed to build a more complex computer simulation to take into account those factors he was forced to ignore during his "first-cut." Unfortunately, this sort of approach is not as useful for complex social issues. In general, analytical solutions to social problems are not complex enough to capture the effects of the major variables. In order to obtain a reasonable understanding about how social systems behave, we must start with a much more complex model. System dynamics allows us to model complex phenomena using systems of higher-order non-linear differential equations. Once linkages are established between the major variables, a digital computer is used to iterate a solution.