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SYSTEMS MODELS FOR TRANSPORTATION PROBLEMS
Volume IV: The Development of Urban Dynamics and Its Possible Regulation

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FINAL REPORT

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16. Abstract

In this final volume, the kinds of extant modeling are reviewed; a hard social physics is outlined; a theory is developed for the thermostatic state of complex systems (here, the social system); using the United States and some American cities, a first round estimate is made of the thermostatic state; the underlying potentials that govern the spatial character of a settlement are outlined; a theory of technological growth is proposed; and the means by which the transport fluxes are related to the potentials are suggested. This closes an introduction to the physics of society and how it may be used for regulation and control; e.g., transportation design.

It appears that man, like all other systems — e.g., rivers, plants, animals — is tied intimately to the earth and the earth's potentials.

This is Volume IV of four volumes.

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Preface

The study has progressed to a point where the thermostatic potentials that govern a social system - nation or urban - have to be defined. The transports in that system can then be linked to these potentials.

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A Consideration of Urban Processes and Dynamics

In our prior reports we considered the general processes that governed national and urban areas from a social thermodynamic view. In order to help us focus our attention, we asked permission to use American cities of recent times as focus for consideration.

At our request for a specific urban area to consider we were given Boston, U.S.A. The choice was governed, presumably, because of the considerable amount of data available for Boston.

For some general background references with which we have begun to interact we offer:

J. Jacobs, The Economy of Cities, Random House, New York, 1969.

The First Cities, Time-Life, 197

P. Gould, R. White, Mental Maps, Penguin Books, Baltimore, 1974.

G. Suttles, The Social Construction of Communities, U. Chicago, 1972.

P. Aries Centuries of Childhood, A Social History of Family Life, Vintage Books, New York, 1962.

Introduction

Our intent, in this portion, is to attempt to develop fairly hard network descriptions of urban settlements as a precursor to regulation. As per our assignment, we will use Boston as a quantitative measure for issues whenever it seems appropriate. (Or any American city for which we find data).

Start up issues "A city does not grow by trading only with a rival hinterland. A city seems always to have implied a group of cities in trade with one another". J. Jacobs, The Economy of Cities.

One need only read Jacobs' book and our September 1973, December 1973 April 1974, April 1975, U. S. Army Research Institute reports to note a fantastic degree of similarity in spite of an enormous gap with regard to our disciplinary starting points. Clearly Jacobs' work precedes ours, but we have drawn ours independently. The point is made, not for intellectual brownie points, but to indicate that we have shared common perceptions from the same experimental data of history.

So our intent is not to quarrel with Jacobs, but to use her work dialectically to establish a firmer basic understanding of the start up and growth of urban settlements.

Jacobs' notion has upset traditional thinking. First, she says, cities came into existence, then agriculture. We will not accept, exactly, either view, the traditional view or Jacobs' view, but take a position that is remarkably sympathetic to her view, yet with corrections.

We noted in our April 1975 report (p.19) that dating the end of the ice age in Europe seems to be narrowable to 12,000 $\pm$ 800 ybp., i.e., 10,000 B.C. Observationally, one finds evidence of rudimentary start up of agriculture, metallurgy, pottery back to that date. Observationally there is no evidence for rudimentary start up of fixed urban settlements before perhaps 8000 B.C. Thus in some crude way, there may be a gap of the order of a few thousand years from very primitive pre-village and village settlements to constellations of trading settlements. By 7000 B.C., there is much lesser doubt that a few constellations of settlements, with significant urban centers, have begun.

Thus we tend to favor our sequence of events. The end of the ice age dispersed the driven melting edge of the glacier. The warming period dispersed a complex system of rivers, and lakes all over the 'temperature' zone (as the remnant marking of the glacial age). Ecological stability favored those flora which could best fit the newly emergent warming climate. 'Weeds', rapidly growing in open lands near water supplies, grasslands, were quite advantaged. Of the families, why wheat and barley were particularly advantaged (or corn in the New World) would require a separate investigation. Nevertheless they were advantaged. And it is quite possible that Jacobs' story about how humans selected seeds and put selection pressure on their hybridization may very well have first taken place via the fauna. Namely grazers and ruminators and other plant-eating animals would likely also have dispersed after the disappearance of the glacial melting front. They then too would be attracted to the plants who were attracted to the water supplies. And then the predators, and then man who had become the most superb hunting animal of all (having had 30,000

years of genetic heritage, plus a 2 or more million year epigenetic heritage of tool using) then would follow the grazers, and small and large predators to the same water courses.

But now, very much in the spirit of Jacobs' story of New Obsidian, but recast physically, we see the following dichotomy:

We have two comparable energetic processes. One, the extension manipulating (tool-using) nomadic hunter; two, the extension manipulating (tool-using) settled agriculturist. Both have a learned process for conducting life. What emerges? As Jacobs describes, a symbiosis whereby the nomadic hunter specializes his hunting (e.g., to tool material, to live animals, to far removed foraged material, such as well preserved seeds, nuts, etc.); and the incipient settled agriculturist specializes his fixed style to gathering, harvesting, animal husbandry, tool making, manufacturing, etc. Where does this process take place? In the newly forming constellation of cities.

So in our view of the historical sequence:

hunting-gathering
warming of the earth
incipient agriculture
symbiotic ingathering of hunter and incipient agriculturist into a network of small settlements
urban settlement formation as trading market place
urban settlement
urban settlements
farming, husbandry, manufacturing, trading as functions associated with urban settlements.

As Jacobs reports Mellaart's comment on Catal Hüyük's economic base, "This was not a village of farmers, however rich." It had a creative economy, which in her opinion - and ours - included agriculture, but its agriculture did not 'cause' the settlement.

Jacobs tries to make the point that the city came first, and then its agricultural support. "At the time the city work of growing grain and raising domesticated animals developed, there would, of course, have been no such thing as rural agriculture, nor would there have been agricultural villages or settlements of any sort specializing in agriculture. In cities, agriculture would have been only a part of economics much more comprehensive, with intensively pursued commerce and industries." We will accept most of her ideas of city development if she not insist it represents start up.

Examination of Flannery ("The Origins of Agriculture", Ann.Rev. of Anthro.2, 1973) shows cultivated plants in the Near East and Eastern Europe back probably to 8500-8000 B.C., in Meso America probably to 5000 B.C., in Peru probably to 3000 B.C. "Cultivation may have begun after village life was already established in some parts of the Near East and Peru. In Mesoamerica and Southeast Asia, cultivation began during a phase of nomadic hunting and gathering; and in Mesoamerica, at least, nomadism continued for thousands of years after farming

began." "Although hunters and gatherers know and classify hundreds of wild species in their environment, they do not necessarily use them all. [See how the mountain gorilla fills out his daily diet by a great variety of choices.].. they divide food resources into 'first choice', 'second choice', and 'third choice' foods,... On the basis of archeological data, virtually all the important seed-crop cultures were derived from species which were originally 'third-choice' foods; they were, among other things, more work to harvest and prepare, often requiring grinding which Pleistocne hunters were ill equipped to do." So at 20,000 B.C. they were not used by Near East hunters, at 8000 B.C. they were not used by hunters in Mexico and Peru, etc. Thus with settlement, then they could come into their own.

These seed crops had certain important characteristics that the 'first choice' foods didn't. They were annuals, they yielded a large return of 200-800 Kg per hectare, they could be stored easily, they tolerated disturbed habitats, they were genetically plastic. And thus, with selection, they responded with favorable genetic change. (Flannery).

Thus you had to settle. And as increasing density of small settlements are reported (see for example, P. Van Doren Stern, Prehistoric Europe, Norton, 1969; S. Piggott, Ancient Europe, Aldine, 1965), agriculture preceded cities and extensive trading communities.

Why these hunter-gatherers selected a decision to work harder by using 'third choice' foods is still not certain, according to Flannery. He believes that they had to, not that they wanted to. Our notion is that the natural stability confluence of water supply, plant, and grazing animal made it the plausible solution for an epigenetically cognitive animal in temperate zones after the ice age. Notice the same story is not found in tropical climates. Settlements can take place there, but there is no extensive thrust for cultivation - as long as the vegetation is lush. Although the carrying capacity for the species tends to be low, i.e., the ecology has a precarious balance - not in toto, but for any particular species - , the conditions favoring competition.

Thus the city came after; after a network mesh of small agriculture settlements, and hunters and gathers, and all the other conditions that Jacobs discusses. The issue is not an ego matter or a semantic matter on our part. Rather that by a sustained strengthening of alternate processes, including the establishment of a network of both settlers and wanderers, the conditions for a city and a trading constellation began.

This is most important for continued survival of cities. The 'ground' potential for their existence must be preserved. Yet on the other hand, their existence was facilitated by various favorable and unfavorable crises and turning points which succeeded in quantized attractions of populations to the city.

This might imply a 'Malthusian' growth of cities to catastrophe.

We believe not, as with all other 'living' systems regulated processes exist. Namely, as Pareto put it, there is always a counter process, by which holdings are raped without discouraging future investors. Namely excuses for escape from the cities will take place.

But our present 'turning point' (refrigeration and transportation) made the suburban flow possible, and created our current crisis - the 'death' of center city.

A very perceptive note may be found in a review of C. Duffy, Fire and Stone, by Col. M. Boatner. He states "Duffy makes it very clear that fortress warfare had a great effect on political and social life, not to mention such special fields as science, technology and architecture. ...The author makes the startling observation that the constraints on urban sprawl dictated by the defensive plans of fortress cities resulted frequently in a higher quality of urban life than we know in today's core cities. Unable to flee to the suburbs, citizens mobilized their best economic and intellectual talents to enhance living conditions within the crowded cities. ... for city life...the siege cannon...turned out to be a creative force."

This is the basic issue confronting us, in a social physics. It isn't until the system becomes sufficiently fully interacting that the elite can see their futures tied up in detailed planning. Thus our program is still somewhat premature historically. And we cannot have recourse to the Marxian notion that we can make history out of our ideology. So - instead - we are early sounders of what will have to become a wave of the future, namely planning. The issue, far from popular in the U.S.A. today, yet, is what kind? Perhaps surprising to both left and right wing critics, our optimal recommendation is for a mixed socialistic - capitalistic strategy, which we believe is the lowest thermodynamic state. We might be criticized on both sides, but our critics will have to realize that we are earnestly defending our own nation against a rapidly developing network of Communist oriented countries. We believe that they may become quite dominant within the next few generations, but will nevertheless suffer their own conflicts. At the same time, a smaller strong capitalistic core of nationalistic effort will continue. But we stand some chance of evolving toward a mixed strategy which may be more suited for perhaps 5 generations from now. Is there a possible national will? We doubt it.

A theoretical note. In work we are doing in systems' biology and systems' physics, a very peculiar confluence of ideas have taken place which helps us to fix the physics of such systems' processes.

We had begun to develop the notion that form emerges out of functional fields when a conflict between two force systems, both of which have to continue to exist, come into contact in a given field. The reconciliation is an inhomogeneous precipitation of functional form. We have advanced that argument for the basis of arterial, mammalian, kidney, neural net, and river development, and could easily pursue it in many more systems.

We were highly pleased when our neurophysiological collaborator, R. Llinas, suggested a much lesser degree of localization of neural function than neuroscience tradition would have. Russian work of Anokhin, Gelfand, Shik, to name a few investigators, or a British sensory investigator like R. Gregory, have all begun to enunciate similar themes.

Finally, a mathematical-biophysical colleague, K. Kornacker, offered us his hypothesis. New brain function comes into existence when two competing regions in the brain both take over some older more primitive function in different ways and lock in its new form. The older regulatory form doesn't go away, but persists in its basic form to provide assurance that the process will not stop.

It seems to us that these are three physical facets of what is emerging as a common evolutionary developmental theme. Inhomogeneous appearance of new form arises from the common quantized stability of apparently competing processes locking into a maintained reinforced resonance.

As applied to cities, we became sympathetic to the notion that competing aims are locked in to form structure of a constellation of cities, which then takes up its agricultural support, by whatever means necessary. Up to recently this had to be quite close. With refrigeration and transportation, and new technology, that support could move away.

But then clearly, a common base was required for the competing aims, and that became the new thermodynamic variable of value-in-trade. But in order to support that mixed notion - mixed because it was materialistic (physical materials or services) and idealistic (mental) - one <u>had</u> to develop thermodynamic potentials. This means that the conflicting aims had to be conducted with a common value system potential (a social temperature), and at a particular technological flux rate (a social negentropic function).

A worthwhile note to insert is our forming view of what it takes to support post Neolithic civilizations. First there must be a strong network of agricultural settlements spread widely over the land (its biological analogue are the microtubules and microfilament structure that seem to underline cellular processes). Because these exist, it is possible for cities to precipitate and organize a large amount of effort and flux. Because of a city network, it is possible for nations to further organize internal and external conduct. The land governs its own potentials.

But there is a considerable amount of independence among these three networks. The primitive settlement network, like capillaries, can be disrupted and torn, but they reheal and regrow. The cities also wax and wane but they do not destroy the primitive netowrk nor the nation. Nations rise and fall too.

But basic is the existence of the settlement network, and the mobility of human atomisms.

Thus in our view, the formation of an urban settlement can be regarded as beginning by an additional spatial ingathering of a few handfuls of people around some fixed style of action that will support a materials balance, energy balance, population balance, action balance, and value-in-trade balance, while continuing to develop an umbrella of a value (system) potential (social temperature) at a particular technology flux rate (social negentropy function - which produces greater or more complex social order).

The value system which developes is multidimensional and itself is evolutionary. It starts, most likely from the economic nexus for which the urban settlement was founded, e.g., the trade of scarce resources between groups in conflict as to action styles of life. (Else everyone would have cooperated in an older pre Neolithic action style of life.) A ground rule state has to exist so that survivorship is insured. But that quickly becomes 'political' and 'cultural'. Why is there a difference?

If each human could play an independent role, political and cultural might not be so distinct. But political deals with the rules of conduct of the many, whereas cultural deals with the rules of conduct between individual atomisms. The political solution is taken from primate ancestry. A new boss monkey barges in and establishes the priority of his rule. Then the people follow. In humans, that breaking in is more sophisticated and encumbered by more neural concomitants than in other primates, but its form is more primitive (e.g., more like cannibalizing fish). It establishes complete domain, including killing of one's kind. This irrationality is part of man's cognitive mind. Thus the personal command of power over people is a peculiarly human process property.

But the individuals tolerate that command if the community develops a common cultural code of behavior, namely how individuals should act among each other. Again the rules are irrational, stemming from the human neural structure.

Thus value systems do not insist on a highly defended political structure - the populace will accept what elite rulers will impose, but they insist on a tolerable code of conduct.

What does that conduct code start with? It starts with another ancient primate process. Mothers and children, and more incapacitated (e.g., older, sicker) people must be relatively safe in the nearby fixed abode.

In earlier hunting cultures, children and slow mothers and old were a drag. Thus few pregnancies, or at least few to term, child and old person killing, slow population growth. Now that population maintenance was significant, these categories - as well as domesticated animals - had to be cared for. Thus a value system.

Examine all the early 2000 B.C. codes. They deal with the conduct of buyer and seller, of the relation of man to his gods, of the rights of orphans and widows, of the promotion of the welfare of citizens (of the city), of punishment for acts contrary to law by fine (value-in-trade) or corporal acts, of law, of justice, of governance. In short, they try to indicate the duties of citizens and a value system for conduct. We have not been less bound than since the first city codes. And they all imply an interacting trading (and warring) community.

Thus the specific form of start up is not that important. It may vary from time to time and place to place. However it will invariably involve a fixed citizenry, mobile outsiders who come to the city, traders, a farming and husbandry and mining community outside, a constellation of cities. The city will trade and transform goods and, from providing the leading technological impetus, it will support itself from a differential in value-in-trade and goods that it extracts.

But all the more this stresses that the city must be in near equilibrium with its supply domain. It - as an elite element - must also satisfy thermodynamic balances. And clearly - the destruction of cities providing evidence - every so often, perhaps at 1/3 to 1/2 to a full millenium time scale, it falls apart. How and why? It has ingathered too many. Its thermodynamic economic balance as a whole goes wrong.

So somehow we have to treat the operational physics of the entire process. For what purpose? To predict a formal academic model, of rise and fall, for an entire civilizational era is only of academic interest. We sense that it can be done.

It consists of the laws of population growth and ingathering and expansion of an urban area. It deals with the rise and fall, the life and death of the city. Its near equilibrium scale begins at 3 generations. Its cyclic 'history' covers a period of perhaps 15 to 40 generations.

But that is not what is wanted. We can already tell that history. Mismatch too often at the kinetic level of 1 generation and you shorten up the life span. (Human individual - dissipate too many of the yearly epochs of your life and you don't get your 70 years. Yes, smoking, excessive eating, high emotional stress, drinking, are known factors influencing life span. On the other hand, sustained physical work, modest diet are favorable factors. Can you surmise correct cycle value systems from such known principles?)

So clearly, clearly, clearly, we are up to the war-to-war one generation epoch. Can't that be lengthened? The urban region, unless it is designed as a siege city - and literal siege cannon literally wiped that epoch out - is not that free an agent. It is involved in a vicissitudidous outer world. Thus it can mitigate but not prevent wars.

> With the current level of international interaction, if we simply take the interactions implied by the current headlines, are American cities independent of uncontrollable events in Portugal, Spain, France, West Germany, East Germany, Italy, Switzerland, Greece, Turkey, the USSR, the Arab countries, Israel, India, China, Taiwan, Thailand, Japan, Phillipines, Southeast Asian nations, Canada, Mexico, Brazil, Chile, Argentina, a host of small African nations - it is almost pathetic to omit yesterday's giant, Great Britain? Two generations ago, the most probable answer, was largely yes, but no longer. And while the line up issues may change from international day to day, the interactions will not.

So our attention must turn to the social physics between wars.

So we are not concerned with initial start ups, except when useful to

illustrate specific points. Rather we are concerned with the city from war to war, and mentally we can always start the epoch after a last war.

So this means generally the ingathering at the end of some war, the slow remodification of a value system and the working out of a materials balance, energy balance, population balance, action balance, value-in-trade balance, within that value potential and the particular technological flux rate. The system becomes more determinate if one recognizes that it also includes - at the start time scale of one generation - a perceived threat variable somewhat specific and independent of the value system. In time of a few generations, that perceived threat becomes part of the value system. But at the one generation level, the urban settlement is conscious of it separately.

Boston - Introductory Start Up

We don't want to dwell on Boston's start up, just enough to qualify the discussion.

For Boston, we must start with the religious revolution, colonial empire, and the Spanish-English wars.[1]

The religious revolution of the sixteenth century marked the arising of strong nations not bound by the Holy Roman Empire remnants. Thus in Henry VIII, Edward VI, Elizabeth (1530-1600), both the break from Catholicism, English Anglicanism arose, and the strong Calvinistic fracture took place. England's strong national character was formed. And less than incidental wars were carried on with a similar emerging Spain and France (e.g., 1590 with Phillip II, France 1690). But it wasn't until the defeat of the Spanish Armada (1589-1590), and the afterlude to the religious revolution that Iberian strength was broken, and England began to devote her talents to become the dominant sea power (i.e., the Portugese, the Spanish, then the English who became the Portugese protectors, and the Dutch, all of who developed sea-faring empires).

While the Spanish colonies in the New World presented the opulence and culture of Europe. the English colonies were founded by an entirely different spirit. The English had preyed on the wealth of the Spanish conquest, had defeated the Spanish, and were completely ready to become the shopkeepers for Europe and for empires far beyond the seas. Who should colonize these North American colonies? Virginia was first in 1607. Europe was preoccupied by the notion that the wealth of nations came from mines of gold and silver. Thus to Virginia came goldseekers. Only later did craftsmen and farm laborers come, from the English lower classes.

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[1] W. McNeill, The Rise of the West, U. Chicago, 1963.

C. Hayes, A Political and Social History of Modern Europe, McMillan, 1926.

R. Reynolds, Europe Emerges, U. Wisconsin, 1970.

By accident, in the North, in what becomes the states of New England, came immigrants from well-to-do classes. But there were no great lords, no common people, instead a large amount of education. All other colonies were founded by unattached adventurers. In New England, the immigrants came because of a value system. They were Puritans, persecuted by their home government, who pursued strict moral principles, and who sought a land so barbarous and neglected by the world that they might there at last be able to live in their own way. So are the New England beginnings presented to us by Alexis de Tocqueville, writing in 1833.

> Note the story - in a physical sense - which we didn't quite capture fully in our April 1975 report. There was the basic precipitated skein of Roman provinces. That could provide the formative base for national associations. There was the localization upon the Europe-Asian land mass. The Mongols occupied the center and dominated it for the long 1000 year period, the Chinese dominated the eastern end, the Romans the western end. When the western end broke up into fragments, it reformed a number of times, but the technology that led to new agriculture and commerce put pressure on the formation of cities and nations. The occupancy of the center put pressure on free escape (assuming land was there. It was, in the form of Africa, America.) The formation of nations - accidentally called England, France, Spain, Portugal, Netherlands - breaking out of empire (Holy Roman Empire) at a time when technology had advanced to permit better sea going ships, led to free escape. Where? Around Africa, across to America. Portugal gained the African route, via Brazil. Spain gained the Mesoamerican path, and thence over land and by sea to the eastern end of world empire. It just happened that England beat Spain and acquired (temporary) mastery of sea going. And since Spain had discovered gold and silver, England was able to pirate Spain. Without local-national competition such free escape leads to empire, until competition and local counter-processes develop. Thus the routes and empires of the 16th century were governed by the ship technology, weather, and climate, and the attraction materials that suited the economy. Thus a 'core' of occupancy developed. What is fascinating is that the next group that happened to be at bat, the educated Pilgrims who were both accepted and not accepted by mother country, seeking a far remote land away from interference, actually selected a region just outside the border of the conflict. Thus note, because of proximity and climate, the Virginia to Newfoundland stretch was the domain for English, also French and Dutch development. Thus endeth Chapter One - Genesis of Boston. Note it is the enculturation conflicts of the prior 500 years, 1100-1600, that set up the background for Boston (agriculture-cities-active trade-breakup of empire-development of nations-external exploration-development of new external empire). Note it was the prior 3-4 generations or so (1530-1620), particularly its national war-to-war rhythm that set up the boundary conditions for colony in America. We will not assert that the individual kinetic event, e.g., the Pilgrims, was determinate - but given any particular kinetic fluctuation, we can begin to outline a potential history.

The entire American start up relates to the national problems of Portugal, Spain, England, France, the Dutch. It would be tangential to wonder why the Scandinavians, who had the technical seagoing lead 500 years earlier were not

part of the pack. Without stopping for details, it obviously could relate to the fact that (a) the technology was 500 years earlier, (b) their potential sphere - lands north of Newfoundland were in fact too cold and hardy and provided early reason not to continue the process, (c) the sea routes by that time in the North already were competitive from England and France and Germany (namely the Vikings had already been tamed by worthy opponents), and the Northern sea routes weren't that freely available because of cold in all seasons, (d) the Scandinavians had already turned toward interior battles, e.g., Russia, (e) they were at a lull at a time where agressiveness paid off.

The conflicts and the available resources, quickly established winners and losers and spheres of influence. Thus Africa - Indian Ocean went to Portugal, South and Meso America went to Spain, North America went to England, France, and the Dutch. Without going into detail, the Dutch (as the Portugese) were only able to hold on to limited power. The French were also excluded from the sea to some extent. Thus to the largest extent, England emerged as victor of North America.

Because of more ancient cultures in Meso and South America and the accident of its wealth, e.g., gold and silver, the Spanish attempted to build their empire around the rich city vision of manorial Europe in transition to commercial Europe. North America - particularly in its temperature and northern climate - did not offer that opportunity. Instead, it offered the opportunity of hard work, rich farming, lots of land, trading.

So the English population in the New World could forage for itself. How? Trade, cattle, farming.

Before we go further, we need to establish some more theory. Dipping into social physics requires an ever deepening understanding of the thermodynamics of complex systems. Thus we have to add pieces as we come across them.

We start with the notion of dei ex machina from above, below, and two from the sides.

From above there is a deus ex machina, a system which persists, and as a result furnishes a gradient source which can empower and support the system from above in a macro sense.

From below there is a 'mother' source deus ex machina which acts as a hidden variable to support the ongoing process locally.

Now the process from above (acting as a source for gross 'convection') interacts nonlinearly with the local cohesive and noncohesive 'linear' process (wave propagation and diffusion) to provide either a latent thermodynamic homogeneous stability (decay to nominal macroscopic static steady state), or a latent thermodynamic inhomogeneous (engine) stability (movement to a nominal macroscopic periodic state state- a net of standing wave structures). Those two latent states are derived from the deus ex machini on the side - namely, the 'mother' kinetic force splits into two macroscopic aspects, e.g., wave propagation and diffusion, which then operate equipollently at the system's level to create a latent instability. Then the field

explodes out of that instability and produces fluctuational entities - a new superatomism - that emerges out of the latently unstable field to create a fluctuation of atomism that represents the emergent nonlinearly stabilizing entity.

Examples:

1) the big cosmology from above - radiation field and gravitation interact from side via angular momentum - the matter-energy field below supports the processes - galactic atomisms emerge.

2) galactic angular momentum from above - radiation field and gravitation from side via electrohydrodynamic waves- nucleosynthesis below supports the processes - stellar atomisms emerge.

3) solar angular momentum from above - electromagnetic field and gravitational matter from side via intermolecular forces - quantum electromagnetism below supports the processes - planetary atomism emerge.

4) solar radiation from above - diffusion and wave propagation via convection on the side - electromagnetic forces below - atmospheric fluctuations, plate tectonics, hydrological chain atomisms emerge.

5) solar greenhouse from above - atomic - ionic - molecular diffusion and wave propagation, with convection on the side - atomic aggregates from below - geochemical, biochemical chain atomisms.

6) chemical storage from above - biochemical, geochemical atomisms from side - interparticulate aggregate forces (e.g., interpersonal and the like) from below - ecological atomism emerges.

7) ecological potential from above (the living - nonliving chain) - competition and cooperation among species from the side, interacting with weather convection - biochemical forces from below - social atomism emerges.

Etc.

We did not outline the latent instability network. In flow fields, it is standing waves. In cells, it is the microfiliment - microtubule network. In the negative ocean it is 'quarks' (however charming or colored they have to be, now or in the future). In galaxies they are galactic pinwheels and shock waves. In atmospheres it is the tidal oscillations. In the geophysical earth, it is potential Bénard cells, etc. In human social organization it is the network of primitive settlements that then promote the formation of cities.

Second theme - What makes inhomogeneous complexity? It is the bulk to shear viscosity ratio, the action that can be tied up internal as compared to what can be tied up in translation. Simple fluids exist in the range $3 \leq \lambda/\mu < 3000$. With $\lambda/\mu \approx 0$, and $\mu \approx 0$,

there is no thermodynamics, only conservative mechanics. With viscosity (and diffusion) near ideal gas, new equilibrium thermodynamic systems come into existence. They can begin to show process time delays, high frequency 'forms'. They have essentially no significant delay. With $\lambda/\mu > 5$, we begin to find thixotropicity, a beginning of memory. Complex systems with thixotropic properties fall in here. At high λ/μ, e.g., > 3000, the system show extended time delay. As the ratio gets higher, the time delay approaches more and more to a single relaxation, rather than multiple relaxations. Form is frozen out.

In the intermediate range, thixotropicity, memory and historicity begin. The states of the system depend on how they get there. Living systems fall in this range.

Evolution then begins with memory coded by its genetic code.

But, as we have offered, we believe that individual memory (as opposed to species memory) is reliably encoded as a 'temporary' attachment to the material which is genetically encoded, namely that the epigenetic code is an extension of DNA coded material which is not essential for reliable reproductive survival. (As a mechanism we proposed Spiegelman's demonstration that the amount of basic coding that is achieved in amino acid chains depends on the length of time available for synthesis; that under fast processing, the chain is shortened to a minimal 'survival' chain). Thus genetic coding shadows epigenetic coding.

The general principle is that the lower atomism shadows the next higher atomism, in the following sense. If the strong force system were so symmetric at the lower atomistic level so as to lock out all further associations (attractive or repulsive), then no further levels would emerge. But each level is imperfectly symmetric. Thus, from the same force system, but using only very weak residual fragments, the next ordered level can emerge with much more highly colored patterned modalities. (Because the forces are weak, and they can quantize in so many more patterns.)

Thus we now come to the living system level, and we are concerned with a basic problem. What in the living system process makes possible the 'multiplier' effects that dominate 'modern' (post-Neolithic man) economics? In the end, all text books, including now Jacobs, are quite vague as to the fundamental process source.

We know that we have pinned the issue down to the thermodynamics of energy, mass, and action balances, now including a value-in-trade balance, and a social value function (social temperature) and a technological flux rate (social negentropy).

Our general systems' theme has been that atomisms are cast up, by stability issues from some continuum field. These atomisms, clustering and persisting in motions, make up a new super continuum. Stability issues, at the level of this supercontinuum

then cast up, by higher ordered stability issues, the next level made up of super atomisms.

While we have been engaged for over a decade in the description of the biophysical field of the organs of complex living systems (e.g., mammalian, particularly human), we were a little too casual in our projection onto a social physics. Obviously the individual organism was an atomism and society became the social continuum. It was to that construct that we had been applying our thermodynamics. But it just occurred to us that we missed a point.

The field of living atomisms is not the collection of just humans, but the collection of all living atomisms, the ecology as a whole. The human social continuum is made up within that large scale ensemble. It appears over and over again that man's arrogance leads him to overlook that point.

Thus, given sun, and weather, and earth and its resources, we are ready to replay the living game.

The effect of the available potentials is to develop a chemical-physical network. It is marked by persistent cyclic processes, e.g., geochemical, meterological, hydrological, geophysical, biochemical. The sun, shining for 5 billion years in the past and some comparable time in the future produces its entropic burden on the universe. But during its fairly regulated lifetime, its radiation loss can be used by lesser creatures to sustain their more local processes. Thus many of these cyclic processes found on earth lock up for geological time scales, e.g., 10^8 years. To illustrate one of importance to us, oxygen locks up via a variety of cyclic chemical processes to produce a high mean oxygen concentration in the surface atmosphere (140 mm Hg partial pressure). And similarly, there are many other maintained mean state plus cyclic state processes that exist.

What is life? It is a chain of chemical processes, chained both within the individual organism, and among many different species, by which they tap the prime energy source of the sun and regulate their state as well as the state of many other physical-chemical entities on earth. The chain is highly interacting and ubiquitous. It was this point we missed.

Thus - say without man, or without any other species, say primates 10^8 years ago - a near equilibrium competitive process develops among all the existing species. It may at first be only a few of the more primitive members of the chain. But then H feeds on G feeds on F, ... to A. Any particular species, by ecological pressure which advantages it, at some long period of time may evolutionarily change via its genetic code to become relatively favored. Its rise may very well take place at the expense of some other species' decrease.

Somehow the basic issue of a 'multiplier', whether economic or ecological rests with this notion.

Now the basic problem is the following: If we put a series of

chemicals into solution, the law of mass action tends to dominate what final equilibrium concentrations they can reach. The addition of catalysts will not change final concentrations of the reactive species, only the speed of reaction by which the final state is reached. This is equilibrium; it represents homogeneous, chemical thermodynamics.

The only way that relative concentrations can be changed is by inhomogeneous processes, the formation of two or more paths that provide deus ex machina from the side. And these must cooperate to produce latent field instabilities.[1]

This implies that inhomogeneous engine processes have to form. But the ensemble of all living species demonstrate that such engine processes can form and in fact do form to map out a connected latent network for living species. Living species then form.

But now how does the next bootstrap process take place? We indicated how. Namely by forming subensembles a particular species can bootstrap, by genetic changes,to develop a more advantageous position in the ecological network.

Thus higher engine processes form. These are ecological engine processes. From coalition, competition, feedback, symbiosis - by a few handfuls of such strategies - the individual species changes its relative position in the ensemble.

For a Carnot cycle, the efficiency for potential sources is given by $(T_1 - T_2)/T$ where the temperature difference is that of the two reservoirs - source and sink.

But there is a related cycle efficiency for a flux source. Thermodynamically, half of the flux power can be tapped. The other half is lost in the internal processes. Thus with 2 cal/min. cm^2 from the sun, what is available for engines is 1 cal/min.cm^2. If living species were capable of tapping the sun most efficiently, they would fill up engine niches, with a considerable amount of multistaging to that level. Any species could only 'multiply' then at that level. But the earth's species haven't reached that level. Thus any particular species can find itself a new niche, or borrow from others.

This would be the story for any biological species. But man has had a special characteristic. Since post-Neolithic times, he has begun to run his cyclic living process by borrowing from the earth. These may be material for tools, or material that can be lived on thermodynamically.

Other species borrow from the surface of the earth and return. Man has begun to borrow from the earth and not return (not effectively).

If the earth potential were infinite, man could borrow forever and at increasing amounts, only rate governed by maximum possible conductance. (There is a pecking order for conductance. It changes

[1] There is increasing attention to the underlying science. See, for example, Science 189, 984, Sept. 19, 1975.

from molecular conductance, to eddy conductance, to man governed 'intelligent' cognitive - coherent conductance). He could apparently violate Carnot cycle efficiency from the sun. He has begun to operate as if he could do so and continue. (One only has to read avante-garde science fiction which has always claimed it could anticipate science to see this belief.) But thermodynamic reality has begun to pull him up, not as sharply as it should, but that is one of man's problems.

So, suppose we are a city, there are three ways in which we can achieve a multiplier effect. We can invent a new productive - good - service scheme. The other community can pay from it from stored value-in-trade, which is finite and can run out. It can be paid for by turning over assist material from the ground faster so as to produce value-in-trade from nonrenewable resources. Or it can be paid for by them inventing a new scheme of their own. In any case, we achieve a local multiplier effect, and overall we have either shifted the balance among the living chain, or we have taken more nonrenewable resource from the whole earth, or we have tapped the storage resource of some other city.

By this means, we can begin to see the global picture for any given urban area. Let us examine a few of its problems, and some ways that we see for fixing them. We have American cities in mind, cities that may be near 'death', or perhaps sick (or even healthy), rather than start up cities in Africa.

First, clearly we have not been near starvation. Thus the problem has been one of relative distribution. Even today, it would not be highly expensive to have good food cafeterias wherein anyone who declared themselves poor could go in for meals. An advantage would be that the opportunity to proselytize, help advise, admonish, teach would be right there on the spot.

Second the same type of solution - barracks without kitchen facilities for example - could be provided inexpensively for living quarters for all poor people. Again the opportunity for education, for moving up to halfway homes, to learn social values could be provided.

Now we don't insist that our solutions be accepted - socialist, charity, or what. We simply point that technically the problem can be inexpensively solved (inexpensive as compared to current costs).

What prevents it? The answer is, surprisingly enough, that there is a middle class and an elite class (not all, just some) who make their living off the poor. They buy shoddy goods cheap, and sell to the poor dear. Note that it is this class which is parasitic on the society. It would be cheaper for the society, if all invested money had to work at socially productive tasks rather than off the 'intestinal-dregs' of its own society. We submit that this is a more significant cause of urban decay than any other single cause.

When things are going good in a city, and new products are being developed, we do not object in any way as much to entrepreneurs who

live off poor people and pay them low wages. At least they are moving things and people into an upgraded state and style of living. That is how they attracted the poor people to the city in the first place.

But it is the second step, that when the initial impetus runs out, and the poor population is kept poor and confined that the urban troubles start.

Then the entire chain starts - limited marginal employment, unskilled labor, flight to the suburbs, etc. There can be no upgrading mobility. There can be no outward mobility. There can be no meaningful core city, no meaningful 'level of services' for the remaining populace (i.e., the notion of bringing in manufacturing by low cost help is a fallacy. It guarantees death, in time.)

A recent conference of mayors (July 1975) indicated what was on the mind of these command-control nonelite governors of urban area processes who were in trouble. Their theme - how to save cities from economic crisis. Those mayors without the troubled cities' problems (at the time) could care less. Their perceptions - an inadequate tax base, flight to the suburbs, unemployment, inability to continue services. Their solutions - they need immediate cash for immediate relief, they need guaranteed regular general revenue sharing that rises to meet inflation, that is in proportion to need say as measured by unemployment, they need a reordering of national priorities. No where was there an expression of what it would take to fix up their problems in some basic constructive sense, other than a remedial sense.

On the other hand, Lou Harris (Harris polls) addressed them in a talk that was characterized as "gutsy" and "telling it like it is", which pointed out that the American populace was tired of half truths and p.r., and that it was time for truth telling as part of political reality.

We attempted that theme a few years ago to control engineers, without any significant enthusiasm on their part for its merit. Our point was that for thousands of years, the notion of the action of gods dominated man's thought, that starting in about 1500 the notion of man responsible for and developing his own future began, leading to the Reformation, the Age of Reason, the ultimate fall of kings (which, as national kings were just beginning to come into their own at that time as the only ones who could resist the notion of Divine Providence, as interpreted by priests, by interposing their own being as divinely inspired), and the American, French, the English reform, and all subsequent revolutions, including the Russian. But by the 1960's, it was finally possible to realize (e.g., we realized) that rationality was not a sufficient base for determining human conduct. Thus a new realism was necessary neither as pessimistic as gods pursuing their own interests with negligible concern or intervention for man, nor as optimistic as men jointly acting for their own interests. We then pointed out to <u>control</u> <u>engineers</u> that the only basis for running complex systems had to be reliable

measurement of reliable on-line data. Thus one message for a New Enlightenment had to be truth in public office, etc. It is interesting that - post Watergate - this theme is beginning to appear on the agenda.

However, our point was not that such a theme would immediately sweep the world; instead that it was a theme for a millenium, and that - as avante garde technical people - we should try to recognize it early. Thus a populace poll is not an indication of a solid conviction, only of passing fancies. Our problem was to interpret these evanescent dreams.

So our opinion stands. We believe in closer to 3-6-10 generations of near equilibrium relaxations before the theme settles firmly in the planning mind of people.

But we have to do our thing, which is to create a future science, when and as people are ready. So back to primitives and fundamentals. More about the start up of cities and their dynamics.

We will make a second assault.We hope that this trial runs us further up the mountain (from whence we can view the dynamic fields of nations, including their cities). We are influenced both by our previous writing and Jacobs' way of presenting the New Obsidian settlement.

Suppose I and my band want to start up a city. I wish to show you implicit assumptions. First when I walk into an area, I make a judgment as to whether it contains a food chain (namely a network of living species that subsist on each other and ultimately the sun). If there are no plants and animals, I give it up. If there are only plants, I make an unconscious judgment whether my omnivorous dietary capability can make out. My judgment is marginal. If animals are there, I unconsciously reason that if they can make it so can I. So actually my judgment has been whether there is basis for settlement. Whether I remain perfectly settled, or only partly is still somewhat beside the point. But in order to start a city, I have to find a network of human settlements. I, in fact, have to have evidence that humans have been able to survive.

But now, since I intend it to be a city (i.e., supporting a population greater than a small settlement whose food chain directly interacts within the existing food chain), I somehow have to 'condense' or 'focus' a greater content of food chain than the individual settlement. In some sense the food chain of food chains and settlements becomes my food chain. Thus my 'protocity' also becomes a manipulator of food chains, where the atomisms are no longer quite humans, but human molecularities, which can consist of individual living things, flocks, groups, settlements, as well as other cities (just as the level above nuclear moieties,which consist of photons, electrons, and a variety of permanent nucleons,are atoms, ions, and molecules, not just atoms).

But can I exist as an isolated city, feeding on its flock of settlements in some undefined way? No. My location is not perfect.

Some place else there are other supply spots. Thus, I may imagine sending some of my flock to that remote place to bring back things from there. After awhile my foraging primate says that it is too far to go. Besides there are comely females or males (the issue was more likely females) at the remote settlements. So he had rather stay there than fetch and carry. So, using this as one model to illustrate the stability argument, other cities will form elsewhere. Namely the argument is that a network of settlements will precipitate more than one city.

But my reason for sending him to that remote place was to bring back material that complemented my tapping the food chain. Thus I have to invent a basis for making him want to give me what I want. In some sense we share a human value system, but - by his very act of staying where he is - not exactly the same value system. Thus we arrive at a balance by value-in-trade. This process becomes a thermodynamic variable associated with convection.

All this is still manipulation of the food chain until we see the multiplier.

Colleagues considered our use of the notion of multiplier idiosyncratic and not in accord with economic usage, so we had to sketch its fundamental nature.

Consider a multidimensional function of

$$z = f(x,y, \ldots).$$

$$\frac{dz}{z} = \frac{df}{f} = \left(x \frac{\partial f}{\partial x}\right)_{y \ldots} \frac{dx}{x} + \ldots$$

$$= \left(\frac{\partial f}{\partial \ell nx}\right)_{y \ldots} \frac{dx}{x} + \ldots$$

$$= G_x \frac{dx}{x} + \ldots$$

This function G_x, the ratio of the fractional change of z per unit z to the fractional change of x per unit x is known properly in active network circles as the gain. Suppose it is a constant, and suppose - for demonstration purposes - that f has just one independent variable x. Then

$$\ell n\ z = G_x\ \ell nx + \ell n\ C$$

$$z = C\ x^{G_x}$$

Thus we find that the gain G is not associated with the steepness of a local linear relationship but the multiple order of local osculation of the relation. A line has a unity gain, a quadratic

curve has a gain of two, etc. The physical connotation is not curve fitting, but multiplicity of collisions, a multiplier effect. Correctly a vacuum tube amplier has a gain, etc., namely there are small nonlinear thermodynamic local engines involved. Erroneously, many analogizers use the notion for static curves that have no such causality.

Now in mathematical economics, essentially the notion of a multiplier is strictly associated with gain. Thus we submit our use of a multiplier effect is a correct generalization.

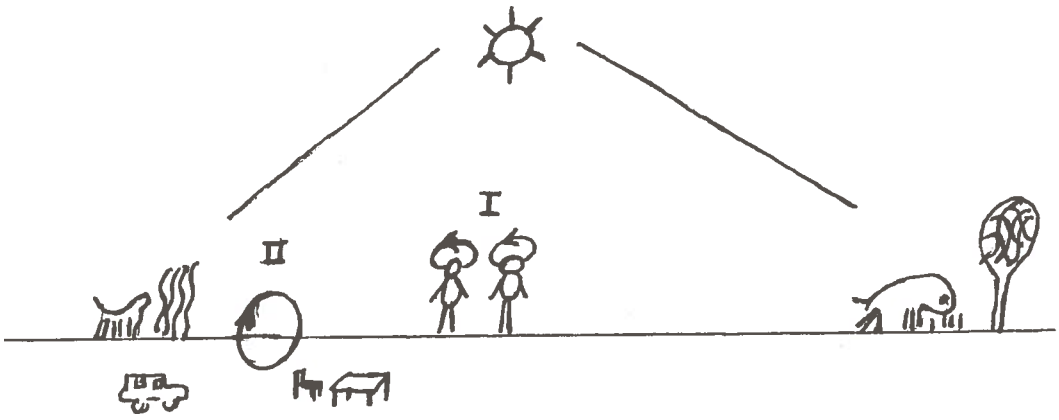
One more note, low global profile systems (example a nuclear reactor, rather than an atom bomb) are operated at gain nearly one levels. A small positive gain above unity is generally evidence of a carefully regulated engine process. In the main we proposed that this is a significant state for us to keep in mind.

The issue we are confronted with is what determines the social multiplier. Namely how can we in a city displace our position in the food change that we get more than a unity gain.

In a unity, more nearly linear gain, we can increase our number by eating more foxes (at the same net absorption cost to the sun), but if they go down, we may proceed to oscillate in predator-prey relation. Well, if we move some plant over so that that plant goes down but more foxes grow and so we can increase, then we still operate near unity gain. Note we have already begun to use catalysts and small engine processes. But more clearly, we want to know where the engine processes took place that drastically changed our multiplier effect. What are we multiplying? The totality of holdings and populations above what was needed for bare survival in the food chain.

We submit that the human uses two engines; one an internal engine - he uses his brain in a problem solving, tool making, manipulating mode; two an external engine - he begins to use material out of and into the ground.

Thus the multiplier comes from the fueling and manipulation of these two additional engine chains in order to support the city and its value-in-trade and its convections from the food chain.



II Chain two - that which comes from the ground, and finds implements for tools, utensils, etc., including non utilitarian structures.

I Chain one - shown as a halo - that which comes from the brain.

That the modern multiplier lays tons of non utilitarian structures on every individual's back has nothing basic to do with the physics of the chains.

Fine, you may say, here is a perfectly satisfactory steady state result. People think up technology, exploit land resources, tap the solar food chain in a more intensive fashion. The world is their oyster in a broader sense. Why shouldn't this last for thousands of years, e.g., until earth resources are used up, or at most show a year or so fluctuation since it may depend on the whole food chain tied to the sun? Namely what makes for the dynamics between these two 'driven' (one periodic, one aperiodic) sources. We must look further into the system.

The very process which provided ingathering to the city, namely by which the exploitation of these two engines - in the brain, in the ground - represented development of a new conductance, a human conductance. Its fueling depends on the perception that instead of spending for immediate gain there is storage, out-of-phase transfer, increased transport which permits an accretion of elements in the food chain, including now the amplifiers. This is not a homogeneous occurrence. Just as the food chain develops around the perceptions of one species relative to another and evolutionary diversity to take advantage of that to establish hierarchical ordering, so the same inhomogeneous instability develops within the city. Some - potential elite, again a network forms - grasp the opportunity. <u>They</u> seek to find and exploit a local conductance. They succeed in funneling the already ongoing multiplier effect. They tap the ongoing food chain which also includes the engines of other brains and other ground ex-

changing engines. They grasp the means of production - of both the food chain and people and things - for their own advantage. Clearly, clearly, clearly, this process involves a fantastic conductance gain. Think - one man can pile up $\$10^5$, or $\$10^6$, or $\$10^7$, or $\$10^8$, or $\$10^9$, as compared to most having piled up $\$10^3$. The multiplier effect is fantastic. Obviously this can only take place if these persons, elites, treat all others as members of a food chain other than themselves. Man domesticates man!

Fine, such catalytic molecularities are needed to keep the overall high multiplier effect going. With elites, the process (e.g., urban) quickly speeds up to a high engine level. So where do business cycles come from; why can't it work at a steady state level? This issue poses us our first systems' spectroscopic level question.

We don't have a firm answer, but we have a beginning answer. It depends on the notion of a social - value - temperature.

Note that the elite are accustomed to large fluxes. On what are their advantageous large fluxes based? We would submit, like all engines, their problem is to get a (roughly) 90° phase lead over future events. If the future were unchanging, if the image of society is of a security, there is little 'short' term reason for becoming concerned. Thus small secure populations do not show abnormal anxieties.

The first perception that strikes humans - as part of the large scale food chain - is the yearly cycle. It is a crap game, a toss of the gods of weather (meaning that the long term effect of weather is to provide a certain pattern of change, as part of a modestly stationary spectrum. Any individual year has a considerable fluctuation in accordance with that distribution). Thus humans are accustomed (in the sense of accepting with a sense of doom) yearly variations. And in fact, one basic purpose of storage - when it starts in settlements and cities - is to wash out the yearly availability from the food chain.

But, as Gamow implied by "One, two, three, infinity", the perception of steadfastness that can influence elite large scale decisions cannot be maintained for more than a few years. Namely, one is forced to near yearly balances. One can vote to continue a policy or change. The tendency of safety is to continue. Thus (not proven but conjectured) a cycle time of the order of a few years, e.g., 3-4-5, would seem to emerge to stabilize the system, namely to represent its 'inertial' overshoots and its lead anticipation. We do not consider this a good theory, but a beginning effort of a theory.

In any case it suggests that elite - looking at their highly amplified gains which fluctuate much more wildly than the food chain it is coupled to - begin to develop a nonlinear resonant limit cycle from the coupling to their anxiety - euphoria mental processing.

(Note at a much higher frequency, one finds the same causality at the near day decision level. Thus a few day economic cycle also exists. See its sustained jitter in the stock market. This reinforces the notion that brain cycle instability near strongly driven natural periods can and will take place. But, again, it doesn't constitute proof. Namely we are still only feeling our way.)

Thus one ought to find this kind of mini-association. A sustained atomistic process in which the elite couple to the populace and the food chain. We have little doubt that the dynamics permit populace and elite to couple in to lock up the process.

Thus, assumption one, beyond the yearly fluctuation there is a sub-not-quite harmonic limit cycle resonance that marks the cyclic fluctuation of the urban region's economics. This represents modern society social 'noise'. As such it provides a microscale for social events in the city (e.g., political decision), which may be advantageous. On the other hand, by coupling too many formal processes to that cycle, without knowing what one is doing, one can provide the most complete form of random chaos one could imagine.

But at least we begin to border the city's spectrum. It has a yearly driven food chain input; it has an elite insecurity based business cycle of the 4± 1 yr. level and it has a war spectrum every 20-25 year generation level to face.

We must make the physics a little clearer. If an ensemble has an underlying atomism (a continued discrete fluctuating entity that carries mass, energy, and momentum), then in ensemble it will make up a continuum with propagative and transport coefficients. But that field, nonlinear at sufficiently large size, by convection, can then go into catastrophe theory or stability theory branching modes that lead to super atomisms arising. The underlying atomism is necessary for their existence, but not sufficient. It requires the boundary conditions of the continuum - the continuum being determined by the atomisms - to produce the superatoms.

Now all of this is quite simple at near ideal gas of one constituent (e.g., dilute ensembles in space). Then one kind of atomism forms, there is one interaction process marked by a mean free path and relaxation time. All internal atomistic modes equipartition.

But when we come to complex organization - complex because of density, complex because of many internally 'sticky' processes - then we do not have a single mean free path and relaxation time. Instead there is a nested sequence of such constants. If one deals with very slow processes, i.e., 3 to 10 times larger or longer than the largest member of the sequence that still ties up appreciable action, then the problem is still relatively simple. The material acts like a simple fluid (mobile) substance again or still. The difference is that some actors will be frozen out (form) and others will be included in. The fluidity relates to the actors who are still included.

But the problem becomes more complex when there is an overlap of observational scale and internal scale, requiring that the physics be conducted as kinetics within a statistical mechanical ensemble, that only relaxes slowly toward the near equilibrium.

That is the problem facing us in human society - post Neolithic. First clearly there is the driven daily cycle of geophysical events - day-night, warm-cold, wet-dry, wind-lull - becoming genetically encoded and epigenetically reinforced. A few day, 3-4-5 day, cycle becomes entrained. In our opinion, it can be seen in the following dynamic processes - the 3 1/2 day water cycle, the social week, the stock-market jitter of elites and near elites. The first becomes genetically encoded, the second epigenetically encoded, as is the third.

Thus we propose that there is a weak atomistic association at the 3 1/2 day level that dominates local diffusive processes. We propose that this should be noticeable in dilute solution societies, e.g., the loose network of settlements in a pre-Neolithic society. Namely one should be able to discover this rhythm in African jungle settlements prior to the impact of modern society on them. This would be true particularly since the yearly driven cycle is not as strong.

We could go back one level to a weaker atomistic association, a 90 minute cycle in man first found in REM sleep, that likely represents an attention function in the complex command-control system, but that would be pursuing the same issue with the neurophysiological field.

Now we face the yearly signal. The entire food chain, most strongly in temperature climates, is faced by that incessant signal. Thus, as we have argued, there is an epigenetically developing 3-4-5 year cycle. We have indicated that elites (running complex production organizations) become caught up in that process. Note that they are forced to make yearly decisions, which is good, because it keeps the system going in lively fashion. But consciously or otherwise, they then are caught up in 3-4-5 year limit cycle oscillations. Clearly we are not in equilibrium. Equilibrium in this living system could not emerge in less than 3 generations, e.g., 70 years. Thus there is a large amount of stirring up atomistic fluctuation that takes place over the equilibrium period, i.e., 15-25 fluctuations. Clearly it is hard to remember what each fluctuation did for the system.

(Try naming the detailed process fluctuations, say associated with presidents, from 1820-1890. The few, associated with tidal waves, you remember.)

But clearly, over a generation, 25 years, there still are enough fluctuations that stir up toward the form of super atomisms, i.e., 5-10 fluctuations. But the numbers are small, and those who understand such kinetics know that the noise in 'density' fluctuations is quite large - particularly as the boundary conditions of the near continuum interact in scale with the atomisms.

But if our recent fluid mechanical work is followed (e.g., Physics of Membrane Transport), one gets the sense that we believe that the 3 year process is close to a Stokes - Einstein near equilibrium process (one for which transport coefficients - of diffusivities - can be defined). A Stokes - Einstein process is the coherent physics (coherent because it arises from correlations) by which an apparent random walk of sustained kinetic molecular processes persists.

At the 3 year Stokes - Einstein equilibrium level, in modern societies, form has already emerged. Populace and elite exist. The elite use the populace and the food chain and the earth and the sun and the mind as domesticable species. The populace use the food chain and the earth and the sun and the mind as domesticable species. What makes the elite? Just the notion of enslaving (a correct technical word, in modelling. The human process) man into the chain.

A dog lets you domesticate him (i.e., manipulate his ego ideal - to the extent that it exists). A tiger, or a guinea pig to a much more limited extent. If you have the total rearing, and know how to take advantage of specific nervous system - command-control system - characteristics, you can succeed further. Man does it quite easily, particularly with rearing and likely breeding. Make no mistake. 30,000 years of breeding has not changed genetic man (perhaps only piddling - read for example, the little difference in genetic character of man and chimpanzee - "Our close cousin, the chimpanzee", New Scientist, 67, 16, July 3, 1975; also see "Evolution of a Gene", Science, 189, 102, July 11, 1975). But it certainly has bred him. And to the largest extent, this breeding has had to depend on how his elite (primate based) leadership led him around. Then, having been led, like by Moses, the populace is bred by the local conditions. Thus hidden variable elites strike out on the new paths, and the populace mass follows and becomes scored (mass before class) and imprinted by epigenetic conditioning to breed what is then needed.

One is capable physiologically of performing back breaking farm work, but to breed - not a race, that may take too long - but a subgroup that adapts favorably to it takes time. Do you think the farmer doesn't select his wife with genetic characteristics in mind, etc.? It pays to read Darwin, for a first time, or again and again (say his earlier Essay of 1844) to get the feel of a naturalist discovering the ubiquity of the process throughout the food chain throughout the world.

So now, perhaps for the first time, we have properly focussed on the weak atomisms - the various molecularity styles of living - elite, farmer, factory worker, etc. as they are known today, perhaps rather than their generic titles, of hunter, gatherer, trader, etc. - and their fluctuating time scale - 3-4 years. And we propose to use the boundary conditions of an urban region which is embedded in a large network of settlements, which then is also occupied by other urban areas. At the present, we do not consider it necessary to do more with the notion than lightly shadow it in. The 'nation' or larger political moiety governs the generation to generation war. We do not think it necessary

to trace a dynamic history wherein there were only one-celled creatures, city-states, that warred. These have long been swallowed up into a more complex multicellular form of 'nations' (a process which itself is not so many civilizational cycles removed. A few city-states, one can remember, still exist, although they had better not contemplate wars. War technology is what ruled them out. Thus there came an evolutionary era at which they could only continue to exist by the sufference of their neighbors, since they didn't have viral defenses. One might note, in passing, that with nuclear weapons of the future, city-states could again become a feasible form of organization. Namely, nuclear weapons could be the ubiquitous 'virus'. If not nuclear weapons, biological weapons could be as powerful. The issue perhaps becomes the question of immune self defense - to nuclear or biological weapons.)

And in that space-time slot, then the kinetics, a not quite near equilibrium thermodynamics, can be played out.

The physical note on that is at the level of S-E equilibrium, there is an extension beyond Navier-Stokes near equilibrium thermodynamics possible. It is known as the Burnett equations. Namely it makes use of near equilibrium S-E transport coefficients, but all sorts of boundary conditions have to be changed. As we have shown, at walls there are accommodation coefficients so that Knudsen slip, Iberall-Schindler rolling, Smulochowski temperature jumps, etc. take place. Locally, we are always aware of the fluctuations - atomistic 'noise' - but a near equilibrium is foreshadowed.

So basically one holds near equilibrium thermodynamics in the mind, and one adds changed boundary conditions, but one has to systematically use kinetic fluctuation calcuations. That is clearly not a sharp scientific definition of the problem. But that was what this project is about, to discover the domain of scientific explanation, and to explore it. At least we can now begin to sort out methodologies for the problem.

Note, to pin it down toward a near equilibrium kinetic state, we have defined two thermodynamic-like variables. These are not conventional, but they relate to conventional - a social value temperature and a social technological negentopy rate. If the bulk viscosity of the mind were not large and sticky, temperature would be physical temperature, or it would relate to a Hull-like neural processing involving the neural fluctuations (e.g., McCulloch-Pitts modelling or for modern versons see Stuart Kauffman or Caianiello).
But the human mind entrains and holds notions. This creates a divergent temperature - value in the mind (40,000 years), and a rate of formation of epigenetic notions, negentropy in the mind (40,000 years) These are discernable as slowly varying functions over the epoch we wish to isolate.

So far for any other species, we do not need to characterize the epigenetic heritage. The same species in separated areas have performance characteristics that can be related.

For humans, we have to specify the epigenetic heritage, the food chain, the climate, the earth resources, then humans can play the game. Even then there are moderate breeding differences. Although our planning will start from a more heterogeneous notion of what constitutes a human.

Since this project is being conducted by a large amount of interdisciplinary discussion it is quite essential to try to bring the bewildered reader along the developing path.

We have insisted to physical colleagues that the model to take for our social physics or social thermodynamics is chemistry. But that notion leaves the chemist confused. Thus we have had to outline the chain to the chemist.

To say to the chemist that he must deal with balances in the energy, momentum, and mass compartments to 'do' chemistry confuses him. He says that he doesn't understand the momentum balance. It doesn't help him when we say that we use an integrated form of the momentum balance to be identified as the action modalities. So finally it occurs to us what we have to show him.

We point out that the chemist recognizes perhaps two, three, or four kinds of bonds, depending on how tightly his theoretical thinking is outlined. Most primitively, the bonds may be referred to as ionic (plus-minus electrostatic) and covalent (quantum exchange process of an electrostatic nature). Thus when the chemist approaches any question of compound formation, he has this minimal notion of modalities in mind.

Or - pursuing the electrostatic and quantum binding issue further - the chemist proceeds up the ladder of organization and has 100 odd moieties (nucleons) organized into eight valence modalities. He knows that he has valences that are zero, plus one, plus two, plus three, plus four, or minus four, minus three, minus two, minus one. With that notion of modalities 'alone' he has some idea of compound formation.

Note, a basic form in this description, is that the momentum balance represented by action modalities has the character of a hidden variable. The compartment must be filled, but it is sufficient to fill it with a cruder grosser notion of the possible action modalities - processes caught up in quantized time - energy packets.

Yes, but the organic chemist says that description is good enough for inorganic chemistry. It doesn't get to the really 'interesting' part of organic chemistry, particularly when one gets to the fantastic complexity of biochemistry (or perhaps a comparable complexity in geochemical processes). Perhaps we might best attribute the discovery to Pauling, but such chemistry begins with the recognition that beyond simple bonding, the covalent bond can provide rich double bonding (i.e., from plus-minus 4 valence moieties like carbon and silicon) of enormous consequences. Thus we have a still higher action association among double bonds and other valence bonds.

And so the organic chemist's modalities relate now to double bonds and association chains. One has to read Flory's Nobel Lecture "Spatial Configurations of Macromolecular Chains", Science 188, 1268, June 27, 1975, to sense the fantastic reach of theory that could be done with some very primitive modal notions.

Thus polymers, macromolecules, catalysts, 'information' macromolecules all become enabled.

Fine, the chemist says, but what or where is the 'thermodynamics'? The thermostatics, the equilibrium process, begins on the following note: Without a great deal of kinetics, the notion solely of action modalities will not give the thermostatics. That begins by summing the energetics over all degrees of freedom. As we discussed in Toward a General Science of Viable Systems, one can begin the computation of the free energy of an ensemble system by summing over the average energy per degree of freedom of the system. For rapid relaxing degrees of freedom, e.g., the translational and these internal degrees of freedom that 'equipartition', physics provides us with quick fast 'gas kinetic' answers. The problem begins with the tied up degrees of freedom. Thus while we have a general theory, it becomes harder to apply. Thus the usual way that the chemist does is to be guided by exact modality laws when applicable, and a variety of guide rates and strategies to apply toward various 'sticky wickets'. He combines experiment and theory in semi empirical ways that represent over and over again the 'practical' path of engineering science.

But in any case, the chemist has a working set of complex guide rules to the underlying spectrum of modal molecularity associations. That guides his notion of the free energy, the gateway to all the thermodynamic potentials. Thus he really digs a thermostatics by a notion of the action modalities that satisfy the momentum equation, and then he deals specifically with mass balances, energy balances - and since he is basically concerned with electrostatics - with charge balances. His kinetics - homogeneous disturbances from one near equilibrium state to another - he treats as relaxations. One must note that he is only puzzled by dynamics when he comes to nonhomogeneous structures. Witness the current stir about the biochemical oscillator. (See for example "Life and the Biochemical Oscillator") Basically, one way or another, the ongoing processes stem from nonlinear inhogeneinities.

And so whatever the level, one must often begin by an empirical search - best guided by some underlying atomistic theory - for the operational spectrum, the spectroscopy of the system, to match its morphological microscopy.

Now for the chemist to move up to the living system, he must see a higher level of modal association. We are still dealing with chemistry, but now it is a physics - chemistry of interacting subsystems - e.g., organelles in the single cell, state modalities among colony members, or interaction via two conduction paths among organs. Modalities emerge. But now these modalities have to get the system to operate in a sustained manner. And that requires - besides the standard compartments of mass, energy, via momentum - action - reproduction.

Even when we jump as high as mammals, we find - analogous to eight chemical families of molecularity associations - about 10 action modalities. If we propose to act as a deus ex machina from above for any species, e.g., to domesticate it, we must know how to provide boundary conditions for or to drive the essential modalities. In autonomous systems, we can't drive; we can only provide boundary conditions.

But reproduction is a choice function that the current generation makes as compared to three generations ago (loosely speaking). Man-play a god-like role - we give you an ensemble of pigeons, horses, elk, tigers - raise them, convince them, just by your boundary conditions to have progeny. Some will, some won't. Obviously their ancestors had a choice function. That's why they are here assembled. Do you know how the circle of variables are tied through the boundary environment to influence the ones before you?

Pretty soon the animal 'chemist' (should we say applied ethologist) has a notion of action modalities. He can quickly learn how to provide the conditions.

And so a primitive notion of 'free energetics' of a living species ensemble is available to this (physicist-chemist) ethologist. It includes the spectral responses for reproduction of an added modality.

Kinetics is a little more complex. Why? Because you must begin to have a notion on how sticky internal degrees of freedom relax. One must understand that it is to the credit of behavioral psychology in general and S. Freud in particular, that some kind of notion of internal processing - hangups, time delays, ideé fixe, repressions, delusions, all processes at odds to simple direct equipartioned relaxation - has developed.

Yet ethnologists, similar to chemists and physicists, are beginning to develop some notions of 'equations of state' as a function of animal density. The studies of Barnett for forest, temple, and captive monkeys were noteworthy ground breakers. And the studies of J. Calhoun and others on extensive colonies are continuing to outline the problem.

The new theme we have brought is that every thermostatics has a neighboring irreversible thermodynamics, wherein the local fields are very near to thermostatic equilibrium, but changes in the field can take place as large scale 'relaxations'. The local near equilibrium implies that it can be described by an equation of state, a free energy function and other thermodynamic potentials. The 'relaxational' processes imply that you can derive some notion of how perturbations - in time or space - will affect the field. And the theory, its nonlinear stability theory, indicates that two kinds of near equilibrium relaxational fields can exist - a homogeneous time independent field, or an inhomogeneous field which may have time fluctuations (turbulence).

Just as the chemist is having trouble grasping this notion in chemical fields (the chemical engineer accustomed to transport doesn't find it so difficult), he is having even more difficulty grasping this inhomogeneous flow dependent irreversible thermodynamics for more com-

plex fields, e.g., living ensembles. Yet clearly he is beginning to recognize it at the bottom of his sustained biochemical processes in the living state.

So what we are doing is not wild, just a 'natural' imaginative leap to the next level.

We have made our first guess at the 'free energy' spectrum for human societies. We suggested that it involved process cycles of 1 year, 4 years, 20 odd years (one generation), and then near equilibrium of the order perhaps of 50-70 years. If one were to follow our biological work, one would see that over a period of years we identified the dynamics that dominated such analogous cycles in the complex mammalian body. If one goes back to physics - chemistry origins, one finds how the spectroscopy of gas molecular processes, and atoms, and complex molecules were gradually decoded and identified by underlying, atomistic dynamics. If we were doing 'pure' social science, we might be able to afford the luxury of detailed stoppages, but we are not. So we have to keep running, and doing these processes on the run. The imprinting in man and natural materials that lead to such cyclic processes are really not hard to conjecture, so we will pass beyond.

We want instead to get some additional notion of what 'running' a society entails, keeping some such spectrum in mind. In particular, we want a little more sophisticated notion on why the social system - at all times - seems to operate with periodic processes, of boom and bust. So far that,we take two classes of examples - we believe they are extremes.

On one side we have modern U.S.A., Imperial Rome, Imperial Britain, on the other side we have late Rome, modern England, India. The issue has nothing to do with capitalism. It has to do with food chains and their exploitation. It has to do with having and having not.

The issue has to do with why do we, perhaps the richest nation in history, persist in having economic cycles, but that even the poorest nations also have them. Namely regardless of whether we deal with a feudal system, a mercantile system, a capitalistic system, or regardless of how high on the economic ladder the system operated, nevertheless agricultural - technological linked social systems seemed to show severe economic fluctuations. Clearly while in some times, 'purely' meteorological causality has been premised, it is not sufficient nor even primary in the generation time scale that seems to be involved.

Thus for this, we would like to put forth a food chain hypothesis that is not weather dominated, though it could easily be entrained by weather.

Let us first put forth the following (late) Roman model, Clearly from at least post Sumerian time on (e.g., the foundation of city constellations), conquest by war was a major means of improving a settlement's economic position. Rome historically (in western thinking) always represents the most superb example of the path of empire and conquest by war. We - in comparisons - are being compared to Rome in her less than later days.

If conquest by war is a way of life, then empire can maintain its cities at ever increasing size. But notice the unpleasantly ending chain you get into. You depend on taxation and booty and slaves for an ever expanding income. But in order to do this, you have to constantly use a larger population of soldiers. Between wars - which you can only conduct at the nominal generation level, people don't like to fight all their lives - the returning soldiers want peace and quiet and reward for their service. So you are faced each generation by an increasing demand for reward.[1]

Villas, whether working farms or not, are only available in limited amount in the homeland, and there is an ever increasing resistance to be rewarded by the hard agricultural work that you avoided in the first place far out in the hinterlands. So you encourage them to settle in the cities. And ultimately it is cheaper to provide bread and circuses and take care of their needs, than to try to put them out to hinterlands. The only requirement is that they breed domestically, soldiers, when you need them. Meanwhile the price of their services goes up for everything. So you have to expand your conquest and taxation into ever expanding regions.

So ultimately that breaks up. Why? For either of two reasons. First, you have overextended your reach to where a counter thrust begins to come about from other networks. (They may have been beaten once or twice, or even not reached, but then they quickly learn from you.) Second, the local populace, whose essence you have drawn upon too often and too severely, themselves rebel and your empire gets shaky internally.[2] Either external or internal rebellions may tear you down.

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[1] It is telling to find a short passing note in an atlas of wars. V. Esposito (ed.), The West Point Atlas of American Wars, Praeger, 1959, "The Spanish-American War - 'the splendid little war' - was, and still is, expensive to the United States. Of the almost 275,000 men mobilized through public pressure, it is doubtful that more than 20,000 fired a shot. In 1959, about 100,000 men - and dependents of equal number - were receiving pensions. To date, almost $4,000,000,000 has been paid, and the annual cost is about $150,000,000."
Examine the national budget for the total costs of past wars. Add to this an additional note that about one third of the working force are employed by government, and one has to adjust one's views of how and what a complex society supports its activities.

[2] As R. Mousnier, Peasant Uprisings in Seventeenth-Century France, Russia, and China, Harper, 1970, concludes that "The immediate and proclaimed motives of the revolts was, in the majority of cases, in France, the burden of taxation imposed by the state, that comparable phenomena occurred in Russia and in China." And also, he points out that there seem to have been too many reasons for an increasing pressure of taxation. The most important was the frequency of national wars and the need to defend lengthy frontiers; military expenditure absorbing the bulk of the state resources. The second reason was the development of more centralized and administrative organs of state with an increase in numbers of agents.

So that was Rome in its later days. No, it was also British Empire. It is the path facing U.S.A. today in its future.

Each nation, each period has its own detailed story. This suggests a profound change in one's notion of historicity. Is each historical story a causally independent complex contour of events? We believe not. We believe that each vortex in a turbulent field has its individual color, but that they fall within a stationary 'statistical' range which is determinate. And if they possess any detailed sequential ordering, i.e., the Marxian notion of a developmental sequence, it is weak. We do not resist the notion that technology proceeds in a more nearly monotonic fashion, but we resist any notion of political development. There may be Markov chains but they tend to circle through the same class of modal systems.

Thus in the U.S.A., it is only post World War II that defense budgets have jumped, also public employment. But if one adds strong unionized labor, amounting to a total of half of the work force, we now see government being involved almost directly in that fraction of 'bread and circus' regulation. (Union influence regulates much nonunion employ.)

Jump, for example, to late Czarist Russia. It had a 70% serf population, perhaps a 25% government employee population, and a less than 5% elite population.

Thus note that an expansionist civilization is trapped at the generation level, to intrinsic periodic processes which must appear in its economic cycle.

Add to this, the memory window in which people in society have no specific memory of causality for more than two generations,[1] and one can begin to sense the powerful nonlinear drives (i.e., low damping) to lock up dynamic processes at the generation level, and the vague reason why a generalized civilizational form of fluctuation takes place at the 300-500 year level.

We offer a key theme, Santayana's comment that those who do not understand history are condemned to relive it. And we begin to sense that history is about a mindless momentum that has no particularly well defined direction. If we were dealing with non human living societies, clearly there is no direction, simply genetic drives and responses to ecological pressure to essentially repeat living patterns over and over again. Those who do not understand history are condemned to relive it.

Man, on the other hand, with a large scale epigenetic memory, is embedded in a cultural matrix that holds 500-1000 year traces of the past. But local decision making is still influenced only by the past

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[1] And in fact if you try to offer them any detailed story of a 'history' of real events they become bored and irritated.

few generations' scale. There is no way in that system, to tell the politician elite (the one who forces his visions on society) on what has to be done for any extended future - 3 generations, let alone 10-20 generations. Perhaps touching base with 'intellectual' (abstract) outlines of reality may occasionally tickle his fancy, but it cannot serve his ego image for the long run.

Oh yes, the human, and living systems more generally, are caught up in the evolutionary and arrow of time aggregation - degradation processes of the long run. So that in the long run, living systems as all other systems, follow a thermodynamic history of larger scale entities. But that is hardly effective - as yet - on the social reactive time scale.

How do we view our modern era, so as to see it no different from the old era?

One arts and culture note (in an analysis of American music) points out that around 1800, with the Revolution over and the cities settling down on the East Coast, some people started getting wealthy, and that with that wealth there was a great desire to become cultured, to get away from the pioneer ethos, to get the very latest from Europe. Thus clearly one effect on the cities as the resultant of the forces building up earlier and catalyzed by the Revolution. Another note (reviewing a book on the history of the 40's) points out that the author, using little theory or conjecture, develops the theme that the 40's were a transitional decade to driving the country into the modern era. Our social continuum was well-defined and grew out of the social and economic upheaval of World War II. What went before was obsolete and irrelevant. [Our notion of the narrowness of the window that governs immediate political action.] Indeed, one can see the origins of some of our most perplexing current problems. Truman's 1947 words, "...policy of the United States to support attempted subjugation by armed minorities or by outside pressure." While the Truman Doctrine saved Greece and Turkey from the Soviets, 15 years later it led to our Indochina disaster. We end with its note that a former president of the American Economic Association pointed out, two characteristics of government in action - that it cannot do anything quickly, and that it never knows when to quit.

Is it impossible to avoid the impression that our 'New World' problems have finally come close to moving back toward European problems (and beyond, even more ancient European, Asian, African problems?) No foreign entanglements? Suspect since World War II. More pressing within a few generations.

The most difficult taste that faces any 'independent' thinker - trying to approach the problem rationally, whether of a 'liberal'. 'centerist', or 'conservative' outlook - is whether there is any means to retain a certain amount of individual freedom in these systems which become so 'quickly' bound.[1]

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[1] Again we refer to no particular political system - whether American, English, Russian, Chinese, French, Arabic, Israel, Spain,etc. It simply doesn't matter. Nor is this pro labor or pro industry. It is simply a question of the governance of the human estate.

Now let's change the setting to past the Roman empire. Has the real process changed? No. Now the fighting for 'empire' is highly circumscribed. Each lord fights with others (we are talking say post Charlemagne - 800). However he again repeats the Roman experience on a small scale. For 1000 years, he conducts fights each generation, in which his serfs and freemen define sharper and sharper rules under which they will work for him and fight for him. His income comes from 'rent'. The rent becomes fixed. And so his empires break up. Some victors emerge, forming the game at a larger scale. But it's the same game.

And when he finally becomes bankrupt, another class takes on the game - as a mercantile, capitalistic game. Instead of war, they change the game of conquest by war to conquest by trade and war. They use a burgeoning technology to conquer empires as great as the war empires. And that works for four centuries.[1] Now its initial chain is expended, and while not dead, it has also been found wanting. The Russians, proposing a political change, have not succeeded in providing a new path, juat a faster way to the bread and circuses route, thanks to a rapid tourney tyranny of Stalin.

As one organizational form of these historical courses are the nations - some through all their lives, some has beens - that have been squeezed toward the margin of subsistence - e.g., India, or modern England.

These nations are even less immune to generation fluctuations. The vicissitudes of each season, in a nation which is too large, with cities that are too large to be comfortably supported by the food chain, with no sources of conquest on which to rely for low cost inputs, these shape the outlook of each generation of what they will accept and what they may attempt to change in limited ways, (e.g., to emigrate or how to bear children).

Thus both the rich who can overproduce 100% of their own needs, or the poor who can underproduce - 5% of their own needs, show generation fluctuations.

In 'good' times (in the civilization cycle) when expansionism is possible by whatever the path of 'conquest', one finds large fluctuations of empire - 'feast' and 'famine'. But when they become boxed, because the cost of maintaining cities as breeding places (for domesticated population and goods, and services) becomes high then the fluctuations die down. But they still are at the generation level.

Mercantilism and capitalism then broke out an alternate large

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[1] Roughly starting from 1600. Although its start up begins with the feudal lords and their servants who caught on that agricultural-commercial efficiency was more advantageous from perhaps 1300 onward.

fluctuational scale of empire. It too has become boxed, and the cost of maintaining cities, as breeding places (for people, goods, and services), has become high, and so again the fluctuations die down. But they are still at the generation level.

So, (a) either we can be innovative and propose still another source for conquest, e.g., space exploration in science fiction, or (b) we have to show how a science can let us live with whatever system level we are at. Just as we cannot eliminate the day-night cycle, or it would require highly elaborate futuristic genetic engineering to change the species for that cycle, we cannot eliminate the generation cycle. Our problem is to provide accommodation to it, to smooth its effects. As we pointed out, in siege cities, if the elite always had to pay attention to their home site, they might care better. But they do not. So we have to ask can we make do with our existing elite? Can we understand the cost of generation's war? Can we understand that a city must not get out of hand, it cannot become bread and circuses, it cannot become too large a fixed and growing charge for services? But instead it must stay tied to its position in the food chain? Again, we are against too big (naturally, we are very little), and too little (right on - too little has little effectiveness), but we are for the just right scale. At that scale, economic fluctuations still go on, but life can be conserved, reasonable liberty can be conserved, and reasonably the pursuit of happiness can be followed. Living systems thrive on hard work, not indolence, but also not tasteless exhausting work. We propose a work ethic not as a philosophic ethic, but as a path for survival.

And as a path back to Boston, we can take a few notes from Reynolds' Europe Emerges, noting its subtitle, "Transition Toward an Industrial World-Wide Society 600-1750". His last two pages refer to the relation of England and New England. We draw upon some key points in the history.

The North American colonists after 1620 were drawn from the craftsmen class, and rural population, but with enough upper-class gentlemen, business men and officials to make the colonies English institutionalized.

As in Ireland, the English established many large lordships. Modelled after foreign empire practise, they also made use of chartered companies.

But a peculiar twist in New England - modifying its 17th century governmental form - was their development of established dissenting churches.

English colonies were largely populated by yoemen (freeholders, below gentry, who owned sufficient, land for his own needs). Their cities were like English country towns of the same time and size. [Note - that had to make a transformation from a forest efficiency

to a farming community while at the same time facing exotic opposition from the Indian. This provided a lot of signal for self-suffiency and community.]

After 1760, the French were eliminated.

Tensions between England and the eastern settlements were economic and social. The population grew, via immigration, as German, Scotch, Irish, and antagonistic Englishmen.

England followed, post 1650, mercantilist policies designed to benefit the ruler and his empire. "Heavy debts had to be paid to take care of the long wars for the establishment of English control in both India and the Western Hemisphere."

The conflict of value-in-trade (money) between England's and colonist's interests was strongly involved. Thus the colonies were forced to look toward English mercantile interests, rather than their own. But - the English taking over Dutch world shipping - this forced a shipping conflict between England and New England.

The colonies knew how to manufacture, but England tried to discourage this so that the colonies would remain dependent on English goods.

The resident upper class felt they should have a large share in local government, rather than short time English officials on the rise. Conversely they still wanted the freedom to be an upper class figure free in English society. Thus a basis for rebellion was laid.

Colonial aristocrats, merchants, and would-be manufacturers, as well as the frontiersmen with their own interests furnished the leadership for rebellion.

Thus from Maine to Georgia, Englishmen who had built a New England, became the first to govern themselves and engage in military revolt. It was a revolt of "The New Europe against the Old Europe".

Outside of the particular circumstances, we see no difference in this history from any other history and empire; expansion, conquest, economic advantage for the home country, over reach and the rebellion of the colonists - provincial Roman against metropolitan Roman; an exercise in surface tension forces, and the breakup into droplets.

Now back to Boston - start up 1620.

We note a conclusion from Aries, "Life in the past [in the medieval towns of Europe, still to be seen in Arab towns and Mediterranean towns in the evening] until the seventeenth century, was lived in public." "Not that the family did not exist as a reality; it would be paradoxical to deny that it did. But it did not exist as a concept" Aries has "studied the birth and de-

velopment of this concept of the family from the fifteenth century to the eighteenth century. [He has] seen how, until the eighteenth century, it failed to destroy the old sociability; admittedly it was limited to the well-to-do classes, those of the notabilities, rural or urban, aristocratic or middle-class, artisans or merchants. Starting in the eighteenth century, it spread to all classes and imposed itself tyrannically on people's consciousness. The evolution of the last few centuries has often been presented as the triumph of individualism over social constraints, with the family counted among the latter. But where is the individualism in these modern lives, in which all the energy of the couple is directed to serving the interests of a deliberately restricted posterity? Was there not greater individualism in the gay indifference of the prolific fathers of the ancien régime? Admittedly the modern family no longer has the same material reality as under the ancient régime, when it was identified with an estate and a reputation."

Since we do not intend to become masters of history we will have to be satisfied with such cues and build from there.

Thus, Boston, we can view as the following near equilibrium epochs: 1620-1690, 1690-1760, 1760-1830, 1830-1900, 1900-1970, 1970-2040 ...(?). The wars that affected it?

The West Point Atlas of American Wars list the following: (Also see R. Weigley, History of the United States Army, MacMillan, 1967).

We start first with the colonial militias (every colony, except the Quaker settlements, had them), e.g., the presence of Captain Myles Standish to train and lead settlers in the bearing of arms at Plymouth.

The spirit of outlook for an English settler was epitomized for the Jamestown settlers in 1607, that they should immediately form into three groups: one to erect fortifications for defense, one to serve as a guard and to plant a crop, the third to explore. Fort and settlement started out as coterminous.

1631 - Massachusetts Bay law that males 16-60 must procure weapons and form units for training, the command of the militia to be conducted by a sergent major-general, with weekly drills (they felt so insecure. By 1637, training was reduced to 8 times per year.)

1636 - General court of Massachusetts Bay organized companies (65-200 men who elected their officers) into regiments, e.g., the North, East, and Boston Regiments. The Ancient and Honorable Artillery Company of Boston was organized as an early Volunteer Militia Unit.

1637 - Pequot War

1643 - Following the Pequot War, Massachusetts Bay stipulated that 30 soldiers in each militia company was to be ready for service at a half-hour's warning. These were made up of volunteers, and the minute men of 1775 came out of them.

1675-1676 - King Philip's War (twice weekly drills. However, by this war the colonies had already lost their forest warfare skills. Thus, for example, in 1675 Captain Hutchinson's column was ambushed near Brookfield, Mass.; Captain Lathrop near Dearfield; in 1676 Captain Pierce with 65 Plymouth Colony militia along the Pawtucket River. Thus New Englanders began to depend increasingly on friendly Indians to scout and fight. Benjamin Church's company, who killed King Philip, was mixed, Indians and whites.)

1689-1697 - King William's War (French and Indian raids against frontier settlements. A New England expedition took Port Royal in 1690)

1701-1713 - Queen Anne's War (Ditto - and again in 1710)

1740-1748 - King George's War (Skirmishes with French, Spanish, Indians - including an expedition of Massachusetts volunteers and British Squadron against the French fortress of Louisbourg - 1745).

1754-1753 - French and Indian War (Including a 1755 expedition from Boston against Ft. St. John and Beausejour and to reinforce Port Royal; also a 1755 expedition led by the Governor of Massachusetts up the Mohawk).

These were the colonial wars Boston was certainly significantly involved in them. Although there was little expectation in these militia of having to fight professional soldiers the colonies tried to get as much military value out of the limited periods of training.

1775-1782 - Revolutionary War

1812-1815 - War of 1812

1846-1847 - Mexican War

1861-1865 - Civil War

1898 - Spanish-American War

1917-1918 - World War I

1941-1945 - World War II

1950-1952 - Korean War

1962[1]-1974- Vietnam War

([1] Past the 1961 Taylor-Rostow mission recommending a build-up in American forces so that there were about 15,000 American soldiers present in late 1963. In 1964, the Tonkin Gulf resolution certainly marked the beginning of a serious state of war.)

We have no desire to linger on the point. Clearly Boston's perceptions were modified by an essentially uniform density of wars, approximately one each generation. This was as true in colonial times - fighting both local and secondary consequences of a civilization thousands of miles away - as post colonial times.

So we don't think it necessary to prove our perception in greater detail - namely that wars have a density effect of one per generation, and that the historicity of culture is 500 years in the making. Further that it represents a thixotropic process - a memory of whence it came from.

Boston - 1900-1970, 1970-2040 is the outcome of the Old European and New European battles of 1400 onward. It has thrown in, measures of African and more recently Asian history.

To repeat Santayana's phrase, those who do not understand history, are condemned to relive it. So we can see the large scale consequences of settlements and value-in-trade. They were conquest by war at the generation level, and the growth of cities. Success was rate governed by military and agricultural technology and the support level of population density. Then technology made another system more competitive - conquest by trade and war. The new technology was in transportation, military, and agriculture.

So let us now whip off a quick word picture of a city, Philadelphia, 1880. We would have done Boston had it been so easily available, but a conference speaker (July 25, Station WUHY) put forth a rapid sketch. We do not guarantee its accuracy, but we suspect its metric is fairly right, not only for Philadelphia, but Boston at that time.

First, it is useful to introduce Philadelphia with the note that if in Revolutionary days (1780), London was the largest city of the British Empire (population 1 million), Philadelphia vied with two other cities in that empire for second place (population thirty thousands). Thus as a first lesson, the very large cities were always related to international aspects of empire rather than purely national. (Every nation did not have a megopolis, but those that had been occupied with large scale empire issues did). Other 'large' cities, the major nation cities were concerned with the effects of war and commerce and war. (The history of Venice is always an elegant example to examine.)

But as we have noted, after the Revolution, some became quite rich,in Eastern cities. We will defer that growth history. Philadelphia too grew.

So in 1880 we find Philadelphia with a population of 840,000, the second largest in the nation. We find a minimum subsistence level for a family of 5, an annual family income of $640. The work week was 10 hours per day, 6 days per week. Skilled workers received $2.00 per day wages, unskilled $1.30. Thus, to live at a minimum subsistence level, the skilled worker had a 10% gap in income, the unskilled a 40%. Ethnically, the population was divided among native born Americans of American parentage, Irish, German and 4% black.

So how did people live? Simply. They did not live from the wages of the father alone. Women and children worked too. Livelihood was a family affair. The usual defects of urban society

existed - high infant mortality, broken families, often with a mother head, they took in borders and lodgers, clothing was second-hand, poor medical care in clinics (with the medical profession objecting to such care), etc.

Since the speaker was expousing the radical economists' views, we might as well finish his story.

Life currently has improved, but with limitations. Living is certainly at a higher standard of satiations, but the gap from rich to poor hasn't changed. The gap remains. You cannot do the mobility transfer from rags to riches. The wealthy came from the wealthy.

Is the transition from blue collar to white collar a shift upward in mobility? This is not the way to look. The radical economists have offered a dual labor market theory. One tests by the following criteria: What jobs are high versus low wages, good versus bad jobs, high versus low security? Most people - women, blacks, other minorities - are in the secondary market, low status, low pay, low security job market. And currently there is a larger percentage of unemployment in these groups than the government selective method of reporting indicates.

In summary, the working society presents a sad picture of reality. When private interests took up the pursuit of the dollar, post Revolutionary days, they were no longer concerned with their community, only with markets.

Next, we can continue to watch, as New York and other cities - the 'unbeknowing' victims of wars and national expansions that have little to do with them directly - try to make their way out of (or into) trouble.

And then we can offer (without reproducing - our contract does not offer us the unlimited luxury of paying for reproduction rights to printed material - while it may be of significance to society, newspapers reserve the right to print all the news that's fit to print to themselves) a summary of East Europe (Sunday July 27, 1975, N.Y.Times, Section I, p.3). Repressions do not lead to revolts. Life goes on, and people acclimate, like domesticated animals, to the rules imposed by their elite leaders.

So we can suspect that the U.S.A. still retains the traces of its efforts 'independently' (having dragged European culture here, but in a mixed form) to conquer its New World (marked by its type of continental weather, and Indians, who validly regarded this as their lands, plus 300 years of black slaves who validly feel they are owed something for the wrench from their African homelands[1]),

[1] It is interesting, in the same N.Y. Times, a black American teacher's editorial on "No Home in Africa", wherein she concludes that although she is not patriotic she is an American product; believing in freedom of speech, even as a token; education for all, even if not equally distributed; democracy, even if it doesn't seem to work. Her roots are here culturally, and there is no turning back.

marked by what has turned out to be fantastic riches in the food chain. But 'now' (the next 3 generations, or perhaps 6, or even 9?) we can only face a relaxation back to the same leadership bickering that has marked all other empires. As individuals, we deplore it. We are marked by our national heritage of freedom. But there is no way to bridge the gap - to drag left and right wing, white and black, ethnic fighting far remote battles, the overriding concerns of the politician to maintain our 'socially free' heritage. East Europe and West Europe no longer sound that different - even if China still sounds somewhat different. And the issue is not convergence to an exact same economic system, but to the same range of socio-cultural concerns. And as we consider the troika of Lisbon an unacceptable abberation, a communistic victory, we doubt that most Americans see it as a typical form of tyranny - the fluctuations among Aristotle's rule of the one, the few, or the many, that have marked all of history. We are bitten by an anti-communist bug (since 1950; the authors have been exposed to that bug since the 20's), when the requirements - for our survival - are a unified pro-democratic bug (to a comfortable rule of the many). We will not persist in that more than 1-10 generations. (Power in the U.S. is being reorder. See K.Sale,N.Y.Times,E 15, Nov.2,1975.)

So - conquest by war having run its course and indicated its typical patterns, and now conquest by commerce and war, having similarly run its course and indicated its patterns (Must you see 3 or 4 more 1/2 millennia examples before you believe it?). What next?

Note, what we are saying - by using Santayana's[1] theme - is that man is engaged in statistical mechanical fluctuations - except for the changing technology. Thus he repeats his behavior, and thus history has related large scale fluctuations. Others, in making such a statement had no science to back it. We have. Thus this is now a scientific statement, not a 'pure' intellectual conjecture.

So we are asking, is there any course which might ameliorate the course of human events, that might please us. We have one or at least a next suggestion - the course of a modern agricultural based society. What is this?

Note, in making this suggestion, we do not imply that the next few generations aren't going to be marked by the rise of multi-national corporations, communist states, national states squirming every way, including subversion, to escape from a gripping poverty. This is the sad - business as usual, if not quite apocalyptic - vision of the future. But beyond that, we see the rise of a new civilizational form. Better? No, just new. It patches up and creates a next millennium of structure to civilization. Namely it will be the acquisition of a 'modern' farming - leading to commerce - leading to war civilization.

The first step - already begun in part - is the acquisition of arable lands and concentration into the hands of a new elite.

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[1] Machiavelli stated that "human events ever resemble those of preceding times because they are produced by men ever animated by the same passions leading necessarily to the same result". True but technology changes.

Wars are not going to conveniently stop to allow this to happen; instead wars will accelerate the process of concentration of land ownership. The modern agriculture will grow out of a technology intensive 'new feudalism', in which near self sufficiency will be achieved while using the remnants of the 'old' technology. Namely, solar power, the less dependence on metals - say by the substitute of high strength ceramics, or organo - ceramics[1], the less dependence on mined fertilizer[2], on extensive genetic engineering to govern the entire food chain from sun to man - and of course a sophisticated defense. As long as other materials are available - e.g., oil for 25-75 years, organic fuels, metals, uranium, phosphates, - the modern directions are not going to disappear (automobiles, atomic energy, etc.), but we are talking about the rise of a new second theme. Its elites will gradually take over, as the nation and commerce elites began their takeover from the 15th century on.

An interesting speculation is that Mao has such an image in mind for a communal nation. Thus the notion is not applicable strictly only to a capitalistic society.

Assuming that the schema would work, and there is little reason that except for the defense issues peculiar to each particular war, and the particular social-ecological milieu in which the scheme develops, that it shouldn't work (it is largely biblical milk-and-honey living by the use of a domesticated human species - the only question is what density level could a modern technology support - how long would it work? It would work until it became expansionistic. Then it would pour outside to commerce and later war. Why? The same differences in perception from region to region, with a convective circulation that cannot be totally sealed off, would develop a commercial circulation, and then later, war. So we do not consider our solution forever, only for another millennium. After that? We have to leave it to future technologists to dream up the next one. We could too (genetic engineering, chemical and physical control, and all that), but at present it would be pure science fiction.)

So - conclusion - cities grow up to serve the convective needs of storage and decays and coupling (capacitances and inductances), and prime movers of a social network precipitated in place using value-in-trade. But their growth and accretion takes place as a result of the conquests of war, and commerce and war. Future systems will have the same need for cities. Their basic dynamics is to be seen at the generation level of wars.

In the U.S.A. their history has been dominated by a sequence of events - the big ones are the Revolutionary, Civil Wars, World War I, II, and the Vietnam War. The smaller wars, before and during were

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[1] One problem of metallic conductivity will 'likely' be achieved by 'super conductive' augmentation of semi-conductor properties. If an elite wanted to pay us now, we know how to start the research.

[2] Namely by a much better balanced food chain. We could start R & D on this already.

also comparably important, but we can point quickly, as an excellent example, the same N. Y. Times (July 13, 1975, Section 7, p.14) reviews a books, A. Lytle, A Wake for the Living, A Family Chronicle, Crown, 1975, that tells a southern history. The author took a 1930 stand on what was wrong with an industrialized, urbanized, secularized America (Read de Tocqueville for an 1830 statement). Now, as an aging and agrarian Southern gentleman he looks back over two centuries of his family to explore and expand and document the human concerns behind his 1930 stand.

His family landed in Delaware in 1724, drifted up to Pennsylvania, and to North Carolina in the 1750's. While the generation was loyal to the King as a colonial official, the next generation served the Continental Army. At the end of the revolution, these officers moved to claim land grants in the wilderness of what is now Tennessee (then North Carolina). Friends and relations joined in a close-knit society; cleared land, built homes, and operated family-size farms, handicrafts and small industry, in a self-sufficient society with little government. In the 1800's, the family gave land for a county seat, a school house, and a church. These were the three basic institutions of Western society. Public business in the courthouse; private at home. Public and private acts separated by the front door, as a symbol. Without knowing the difference between the two is to surrender the delicate balance or order which makes the state a servant and not the people the servant.

Then there were flush times through the 1850's, which was the high water mark of the community. Slavery is defended as a necessary exit that had been inherited, part of the common life since the opening of the country. Grandma considered everyone as members of the family, not a democracy, but a hierarchy.

But then it was absentee - owned plantations, the product of the Industrial Revolution, the cotten gin and English and New England mills that introduced abstract or non familial role and modified slavery. The slave was no longer a member of a family, but like the wage slave of those corporations which grew out of absentee landlordism.

The Civil War ended slavery and created a new nation. The South became an economic province of the East.

Enough. The Eastern and Western, and Northern perceptions each take alternate branching paths through the same sequence of steps. Those trained in statistical mechanics might sense how to write history of an inhomogeneous field relaxation by relaxation.

We hold no brief for or against any side, however romantic or rational. Our problem is to get a vista to view the dynamics, not to write or rewrite, or revise history.

So - as outlining summary:

Post-glacial period, a network of human settlements form.

Focal centers develop, from stability criteria, to exchange value-in-trade, to store, to equalize cultural values. Their 'wealth' often requires coextensive defense.

The network of settlements and centers might remain indefinitely stable (even if only marginally), and in many parts of the world, do and have remained stable for millennia. But there commonly arises, as Jacquetta Hawkes states, "a long and now familiar process; the rough, virile, boldly led barbarians, or 'have-nots', emerging from their particular wilderness to seize what they could not create, the delicious fruits of civilization." [J. Hawkes, The First Great Civilizations]. We cannot dwell on start up issues, but whether the settler invaded the lands of the barbarian, or vice versa, there arises disparities of image of the 'in' society and the 'out' societies. The 'outsider' grabs the holdings of the 'insider'. The issue is not that he succeeds the first time, but in a real sense, attempting this process generation by generation, there comes a time when he succeeds. Thus there exists all gradations from minimal perceived differences, and gradual interdiffusion via sexual and family bonding and the violence of propagative conquest. Thus the rhythms of war, and conquest, and rulership are born.

A larger form to civilization takes place over the following themes: The perceived dualities of birth (of both plant and animal life including human) and death, friend and foe. These led to the mind institutionalized constructs of ritualization, kinship, taboo, priestly go-betweens, chieftain-kings and warriors.

There is absolutely no point in asking why must war start, why must people fight, who presumably could adjudicate differences, arrive at 'equitable' solutions and divisions to perplexing problems, (e.g., all matters which legal codes since the beginnings of civilizations have been designed to deal with)? That is part of the neurophysiological instability of human mind. Put differently, at any place or time, there are actions that stem from perceived cultural norm differences that may be 1 to 1000 generations apart.[1] (Cain, Cain, where is thy brother?).

Thus a third level of organization emerges out of stability considerations in which a territorial network of human settlements and

[1] Anyone can list his prejudices of things that offend him - whether it be body odor, social practise, social behavior, mode of speech, or another nation's agit-prop. We submit there is no way you can handle the outbursts that come from these judgments. Yes, most outbursts are sublimated, but the entire range of what is perceived as command behavior comes from that appreciable fraction that you can't submerge and control. That fraction is sufficient to destabilize the system.

focal centers (ultimately towns and cities) are subject to some sort of regulation from an external authority. Here a diversity of forms arise. One recognized division is a so-called difference between Eastern and Western civilizations, relating to how the cities are controlled - whether directly by outside rulers or by local autonomy. Commonly the ruling authority elects a city base within the network, but it may be ruled as a more remote empire, or the external authority may only be intermittently applied, where the rulers remain nomadic.

When the network region becomes caught up in these external struggles for rulership, generation by generation (for it is the outsider who certainly senses a pressure for interaction each generation[1]), the town and city is no longer independent of these outside events.

Like a multicellular organism, the external control takes over or certainly interferes with some of the basic transport functions of the city. Taxation and issues of defense are invariably the minimal form of interference. The taxation may be in value-in-trade, in labor, in bodies. Almost by definition, there arises a moderately shared value system and technology, for even if it is withheld, in time whoever is victor imposes his, and the network takes it on (not perfectly, not perfectly).

And so the city is forced to rationalize its activities for two purposes. It must continue to serve the network settlement it was created to serve, and it must serve its outside controllers. Thus both a local active elite is created and an external elite.

But the outside controllers are still not fully stable. They, in time, form larger spatial moieties, through competition, which we may call nation states. The very produce of the food chain - nature, and human settlements, and cities - provide a potential for further outside adventure, the very properties that made elite rulers (now of nation states) make them aggressive. Whether to actually attack outsiders or defend insiders, becomes a minor detail. It is clear, from the entire history of international 'law' that a morality for national conduct has not been achieved (or princes and people have different requirements for morality).

International legal experts can tell us, as much as they want, about the amount of progress that has been made to establishing modes or forms of conduct, but as scientists we will not believe them. Our reading of Chinese history shows little difference in the excuses for or bloodinesses of their wars, (except for a proclivity for a large degree of chopping off of masses of heads). When young, we were offered the massacre of the Armenians by the Turks as the last bloody genocide, but we have since had genocides with a regularity and scale that matches

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[1] Examine the listings, empire by empire, of the rulers or conquerers whose names have been discovered in C. Darlington's, The Evolution of Man and Society. Imagine all the others, whose names are not yet known, or lost.

any of the ancients. The current drawing up of European borders is a ratification no different from that of any period of history. An inability to control terrorism, piracy, smuggling (e.g., of drugs) among civilized nations all represent a status with little advance. One need only watch our inability to move in any way toward any basic recognition of human rights, say with the USSR, and in fact to be hard pressed to deter international development of internal 'wars of liberation' (with a certain amount of shared guilt on our side - we have not been altogether on the side of the angels) makes a mocking of any claim to a significant system of law. An arrangement among Mafia-like competitors, yes; guardians of human rights, no!

But again our concern is not morality, but a real description of reality, not as it ought to be, or even as it is, but as it has to be.

Thus only a few patterns can arise for the outer nation state. It can expand by conquest, it can stay in stasis, or it can shrink by defeat or conquest. Stasis is possible, at times, for extended periods. Ultimately the large scale movements of others catch up with you. If you are small, God help you, because in time someone will find a reason for interfering with you. So no small nation state is safe. It can only play a careful international game, e.g., be useful to all sides, and hope.

So there then remains the growing and diminishing units, and clearly they are caught up in waves of empire and decay. And their cities are subject to the transports and fluxes relevant to empire and decay. At the planning level of the individual city, there is practically no interaction back to govern the sequencing of wars.

When it comes to the issue of governance, we have some strong words. First elites arise to regularize the basic requirements of the total economic chain - materials, energetics, actions, population, value-in-trade, value, and technology.

From that very nature, if it is not regularized at the local settlement network (e.g., family, kinship, and friends), it must be regularized at the town or city. Thus this is when the first economic elite (those who govern lots of people-energy) comes into being. He can become wealthy because of the skimming from the transports. If not capacitative wealth, he may settle for its paper equivalent - power, on demand. As we have constrasted earlier, the Russians are infinitely foolish for not understanding this, for attempting central control. They are not foolish because they are Communists - the Chinese are showing an infinitely wiser understanding - but because they are absolute centralists. The unfortunate part of making that statement is the recognition that like Rome, we are becoming increasingly guilty of the same theme. We are attempting more and more to centralize economic authority. And to repeat again, the issue is not that we destroy the capitalistic free market, but that we try to centralize too much.

But there is another corollary to large empire which must be made explicit, As we (USA, USSR, Rome, etc.) get too embroiled in large scale outside matters of influence and empire, our cities become large

scale producers of goods. Its eyes turn away from local needs. It has too much 'national' and then 'international' demand put on it. There thus comes a progression of wars, whereupon the local elite - even if he wanted to - is caught up in larger scale issues. His eyes turn from his community.

The specific point as it concerns our cities is that many of them, e.g., Boston, turned such attention after the Revolutionary War, for the usual reason - in the aftermath of war, many became wealthy.

Thus there is a large amount of pressure on local elites - as a nation grows and prospers - to turn major attention away from the problems of the local community. And the issue has nothing to do with capitalism, Communism, feudalism, fascism, or Eastern philosophy.

And at the national - governing - level, one must understand very distinctly that economic elitism and political elitism are not the same thing. As we have indicated, to retain power, one has to have a different morality outside and inside one's country. Your people must follow, grudgingly or happily. Outside you are limited by your power and your perceived willingness to take chances. Words do not matter. To master those arts is a full scale task. Running the economy is another task.

Oh yes, rulers have attempted to do both by the use of advisors. But the problem remains the same, economic authority is effective in the local domain. When that authority is not there, the ruler may suck its resources dry for even up to a few hundred years, but ultimately its power falls apart and the task must change. So the dilemma is clear. It is the reason for and division of authority between central rulership (including military and external affairs) and local economic balance.

If one recognizes the basic tension of that unstabilizing dichotomy, one will grasp the falsity of much of the discussion of freedom and slavery conducted by all ideological bents; including John Stuart Mill, de Tocqueville, Lenin, etc.

"If all mankind minus one, were of one opinion, and only one person were of the contrary opinion, mankind would be no more justified in silencing that one person, than he, if he had the power, would be justified in silencing mankind." John Stuart Mill

"Agriculture is perhaps of all the useful arts, the one which improves most slowly in democratic nations. ...But almost all of the tastes and habits born of equality naturally lead men in the direction of trade and industry. ...The Americans make great advances in industry because they are all at the same time engaged in it and for this same reason they are subject to very unexpected and formidable industrial crises. ...I believe that the recurrence of these industrial crises is an endemic disease among all democratic nations in our day. ...democracy favors the development of industry...We shall now see by what roundabout route industry may

in turn lead men back to aristocracy. ...division of labor...So there is no resemblance between master and workman, and daily they become more different. ...What is this, if not an aristocracy? But that aristocracy is not at all like those that have preceded it.

"I noticed during my stay in the United States that a democratic state of society similar to that found there could lay itself peculariarly open to the establishment of a despotism. ...Those democratic peoples which have introduced freedom into the sphere of politics, while allowing despotism to grow in the administrative sphere, have been led into the strangest paradoxes. ...For...small affairs...they hold...citizens are not up to the job. But they give these citizens immense perogatives where...government of the whole state is concerned. ...One should never expect a liberal, energetic, and wise government to originate in the votes of a people of servants. ...it is easier to establish an absolute and despotic government among a people whose social conditions are equalthan among any other. ...Such a government once established...would... strip each man there of several of the chief attributes of humanity."

de Tocqueville

The post Reformation, post Enlightenment thesis about the freedom of choice of the social rebel is a major tenet of conservative thinking; with the notion that government attempts to force equality on all as the source of the worse despotism. Let us destroy it as follows: Both genetic and epigenetic pressure in a biological group is to enforce a true breeding of mean characteristics of the group. That breeding has nothing to do with the remaining range of either genetic or epigenetic mutability and mutations being carried.. When conditions change, selection pressure moves the mean. Thus the biosociety moves along in response to selection pressure. Humans have little control over the process. Thus both repressive Communist Russia, in-transition Communist China, and conformist U.S.A. all show centrist conformity. Why else do you think that all outsiders scream about Americanization, about coca-cola culture. (Or Roman in an earlier day).

We have spent enough time in oppressive USSR not to be convinced. We are well aware of the range of freedoms that we have in our country, particularly since we are loyal opposition dissenters from both ends. But we are also aware of how tightly we are culturally locked in, exquisitely so whenever we go out of our country.[1]

The basic freedom that seems to lie behind conservatism always seems to be related to these two groups - the autonomy of the local group versus the power of the central authority. The 'social rebel' that tends to be defended is the local elite to do as he pleases. He doesn't want the centrol power to regard him as the same as all other peasants - whether 'citizens', 'serfs', or 'slaves'.

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[1] Or read a young black's response, mentioned before,(A. Dula, "No Home in Africa", N.Y. Times, Sunday, July 27, 1975, p. 17, Editorial Section).

On the other hand, let us characterize some radical positions. For example, at the time of writing, a troika has been established in Portugal. It reputedly favors direct people's government (i.e., basically a nested sequence of workers' councils) rather than party systems. We can predict with confidence that this is a subterfuge for a communist takeover, although the possibility of some civil war anarchies is still reasonable. Nothing here indicates any interest in equality, freedom, and the possible depotism of equality. Nor was there any depotism of equality in the Soviet Union. The dictatorship of the Communist Party, of its oligarchic leadership, which quickly became dictatorial was hardly any test of equality and some semantic equating of this to freedom or non-freedom.

Also any attempt to equate communism, socialism, social democracy is one further fallacy. An earlier American tradition equated trade unionism with socialism. There is an interesting commentary by Paul Johnson, a prominent British socialist (Atlas, August 1975), p.10,[1] which denies the equation. In fact, he makes the point, similar to ours - referring to the current British trade union movement - that it has become reduced to one operational function, to demand for more wage rises. And since the British trade union movement have become the national, including political victors, they dominate the Government, so they can force the Government to give them any settlement that they

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[1] In the same issue, Atlas, p.33, there is an interesting illustration of how war affects the outcome of cities. The article is one aspect of the recent International Womens Year Meeting held in Mexico City. A highly educated black Uganda politically oriented woman, T. Awardi writes in the UNESCO Courier of Paris, "For African Women - Different Goals". We perceive her writings as the result of World War II and the breakup of European empire in Africa, whereupon political but not economic 'freedom' developed. She tries to indicate something of the burden carried by African women.
"However, in colonial and post-independent Africa the mobility of men in search of employment and education has left women with the full burden of the family. From Capetown to Tunis the drift of men into urban areas and mines leaves millions of women without the protection and assistance of their husbands. Typically, our rural sister's husband left her years ago to find work in the towns. She might see him two or three times a year...They communicate little since both may be illiterate. If - lucky, money may trickle home in small amounts...She must farm and trade to keep herself and her children fed and clothed. ...The towns and mines forget she existed when they planned the one room where her husband shares bath and cooking facilities with other single men. His wage cannot provide for seven children back home. ...he must have his few luxuries - alcohol and a few prostitutes. ...children may not go to school since they are needed to help with the work. Often children drift to the urban area as soon as they are old enough, leaving the rural woman to tend cattle and to plow, harvest, and sow the land. ...To an even greater degree the urban woman is stripped of traditional protection..."
Perhaps a shade exaggerated in oversimplifying the whole continent's problems, but hardly divorced from the theme of how war's results - particularly where rise and fall of empires is concerned - affect cities.

demand, and the Government prints the money, resulting in inflation, etc. (The same point we made in indicating who now dominate their own support level from the central government, and who thus effectively become public employees.) It is hard to follow the detailed arguments of equality and freedom proposed by both sides - radical, conservative - without always seeing the conflict between central authority and local authority. As far as the local populace, it is always infinitely difficult to be certain, what character of 'freedom' they want, except in a coarse cultural fashion. The acquiescent Russian who accepts his system, believes himself 'free' to do the things he wants to. We deplore his chains, but there are others who object to ours. And so it goes, and has always gone.

Look, we are middle class intellectuals. We value all our freedom. We like it here. We conform. We accept. But the problem we now face, in a time of social crisis, is to tell it like it is, like it has to be.

Our point has not been to argue freedom, but to dismiss the nonsense - equality breeds despotism. Equality and inequality breeds despotism and tolerance. But we are not concerned with the individual's perception in developing a social physics for cities. That would be part of the social dynamics of the individual in society. And in the canvas of social ensembles, it is local elites versus their concern with local problems, versus central elites versus their concern with national problems. And we propose that the dynamic evolution of their forms gradually polarize the interests of local elites toward that of the central elites.

Thus, for example, today we find both the elite and middle class having moved away from center city - 15-25 miles away. That distance is sufficient to give them fully the outlook of absentee landlords. Namely we have to be concerned about whether the growth of empire - conquest by war and trade - itself isn't destructive of the status of one's cities. And rather than wait for ultimate destruction of the national system, can we save it?

Of course there are many of both end pursuasions who say leave it alone, that only the doubly hated 'liberal' wants to change it. We are not even trying to be liberal, only trying to understand where we are.

It appears dangerous to be swept up into conflicts between rising empires, and conflicts between rising and falling empires. That, at least, has always been a peasant complaint. In that respect we are peasants.

If we were to take a stand, and we will now, we would be against both too much central interference (American, and certainly Russian), we would find a gentler central cooperation with less government, more conducive to solutions, we would be against many or most current local elites, and most local 'redneck' philosophy. Instead we would hope to be able to develop a new vigorous business - technical local

elite who could comprehend the technical magnitude of the local job and get on it with some compassion. Namely that again would be caught up with their local problems. That, as usual, would be laughed out of court as 'reformist'. Our point of view would be that that leadership could not be parochial. It would have to understand and encourage technological advance, R and D, good theory and good practical results. If in a thousand years it went sour, so be it. That solution is better than continued crisis states every 30 (?) years.

We no longer have any control over Russia, over the world. Perhaps for a little while in 1945, we had some fantastic euphoria which may have lasted 5 years. Now we have to get on with living in the world. And that involves two directions - central authority looking out, and central and local authority looking in.

The crisis of New York, Detroit, Cleveland, Newark, etc., the population centers, is not going to go away. Band-aides of revenue sharing, mass transportation, low interest loans are not going to save them. As the example of municipal employees - Britain, New York, Philadelphia, etc., have shown, the workers are not going to find their own solutions. Neither will a straight market capitalism. Nor will a 'rearrangement of priorities' by government do it. We are neither for nor against growth. What we are for is a rational rearrangement of the local systems and their rational network into a lower profile occupancy of the food chain. And that is thermodynamics.

We are for the vigorous appearance of local elites who see the opportunity to profit themselves, but who see it in bringing together the home opportunities. Perhaps this requires lowering of some living standards, perhaps not - that is not clear - but at least we can approach the theme that was always supposed to inspire the devoted Russian - a good country, should we say countryside, which we could offer to our children and their children.

Back to Boston, Philadelphia, New York, Detroit, Newark, etc. What is it that the future must bring, and can it be affected at all for the good of its people, present and future? To that we must return.

We believe that we have now provided at least some very primitive notion of the class of dynamic processes that influence cities in a spectral sense both temporally and spatially. It will be useful if we try a very primitive quasi quantitative balance for a city. In this step we will have reached the limits of our present contract commitment. Time will not permit us greater detail. But our suggested modelling will tend to pin down the thermostatic properties of an urban area, and permit us - perhaps in a continued effort - to go on to a more detailed accounting say for Boston.

We have discussed our notions of the generalized thermodynamics of complex systems at all levels of discerned organization with a considerable number of sympathetic colleagues - our project officers in the U. S. Army, NASA, now in the DOT, biological, physical anthropological, some social scientific colleagues. They all consider us in-

tuitively right; they all agree that we are on a convergent path - a path in which these notions of physics that, for example, were argued for with such vehemence by Einstein, will converge toward the 'normal' science of their fields; but, rightly, they want more and more of a formal structure of identification. We single out a few recent writings of ours that proceed to lay more detail on the track.[1] For example in the Alza lecture we laid out a rought descriptive notion of the thermostatic state of a living ensemble. In now proposing to tackle this descriptive state for modern human societies, it has proven most fruitful, in discussions with our concerned colleagues, to put before them the following more formal model of the thermostatic state.

An Introduction to the Thermodynamics of Complex Viable Systems
A Note on the Thermostatic State

This essay is offered to physicists, chemists, biologists, and social scientists as an introduction to how the thermostatic state of a complex systems' ensemble of similar atomisms is identified. The method of exposition is by a series of examples. However the notions introduced are generalizable.

Example 1 - An ensemble of simple mobile atomisms of a single species in a single phase (e.g., neon atoms assembled at a gas density).

A. There is a single intensive function that is shared by these atomisms at equilibrium. It is called temperature T.

B. These atomisms, upon collisional cycles, have only three summational invariants - mass, energy, and tensor momentum.

	Atomistic properties	
m (mass)	$\frac{1}{2} m\bar{v}^2$ (kinetic energy)	$\bar{p} = m\bar{v}$ (momentum)

C. In the macroscopic ensemble, locally, the question is what to do these transform into?

	Local continuum measures (per unit volume)	
ρ ($^{gr}/cm^3$)	u ($ergs/cm^3$)	$-p\,\delta_{ij}$ ($dynes/cm^2$)

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[1] Of course, we begin with the major statement in A. Iberall, Toward a General Science of Viable Systems, McGraw-Hill, 1972, which comes from an earlier U. S. Army study. But currently we have a piece, A. Iberall, "On Fashion in Science - a Counter Opinion" under review, which puts forth a counter to the Kuhnian theme, of the paradigmatic changes in normal science as the path of development, by the notion that all science has to converge to the thermodynamic view. Then also see the 1975 Alza Distinguished lecture of the Biomedical Engineering Society, in press, Ann. Biomed. Engin. by A. Iberall, which puts forth themes and content of some thermodynamic descriptions.

Notes: The summational invariant of energy most commonly is transformed into temperature, but there really is a considerable chain of assumptions involved in that transformation. One assumption is that of equipartition. With rapid enough equipartition, we have $du = Cv\ dT$. Cv is the specific heat. Thus commonly u and T are transformable into each other. But T is an intensive quantity and u an extensive quantity. It is more fundamentally sound to permit T to be the shared value system of all the atomisms.

This transformation and all examinations of the other transformations will indicate that they are achieved by averaging over a collisional cycle.

An important thing to note is that the momentum variable really transforms into a tensor. δ_{ij} is the unit second order tensor. It is 1 if $i = j$ and 0 if $i \neq j$. Because of its particular symmetric property for mobile mechanical systems, the stress tensor is a very simple tensor - a diagonal tensor, $\delta_{ij}p$ which can therefore be represented as a vector, or in fact a scalar pressure p. The basic point is that the momentum 'vector' transforms into the action modalities of the system, as some sort of matrix.

D. The equation of state derives from the dynamic constraint that exists among the near equilibrium <u>fluctuations</u> of the summational invariants. Thus the physical statement follows.

$$d\rho = Adp + Bdu$$

Since by definition, these fluctuations relate to the summational invariant cycle, they are themselves near equilibrium, and so they are therefore integrable. Thus the mathematical statement follows

$$d\rho = \left(\frac{\delta\rho}{\delta p}\right)_u dp + \left(\frac{\delta\rho}{\delta u}\right)_p du$$

or, if the reader prefers,

$$d\rho = \left(\frac{\delta\rho}{\delta p}\right)_T dp + \left(\frac{\delta\rho}{\delta T}\right)_p dT$$

Namely there are 'continuous functions' that may be used that really are averages over a quantized time, the collisional cycle. A kinetic theory is required to identify and evaluate the 'continuous' coefficients in order to perform the actual integration up to the equation of state.

Note: The physical law that is the equation of state is contained in the statement about the correlation among summational invariant fluctuations and its integrability, not in the special form achieved for particular ensembles.

E. Examples of the integration are trivial in a general system, but significant as a study in detailed physical kinetics. So quickly as a rudimentary example, we might note

$$\left(\frac{\partial p}{\partial \rho}\right)_T = \frac{C^2}{\gamma} \qquad -\alpha = \frac{1}{\rho}\left(\frac{\partial \rho}{\partial T}\right)_p$$

$$\frac{d\rho}{\rho} = \frac{}{\rho C^2}\, dp \; - \alpha\, dT$$

For a near ideal gas (simple collisional interactions)

$$C^2 = \frac{\gamma p}{\rho} \qquad \alpha = \frac{1}{T}$$

$$\frac{d\rho}{\rho} = \frac{dp}{p} - \frac{dT}{T} \quad . \quad \text{Thus} \quad \frac{p}{\rho} = AT$$

F. Three final notes: How are the summational invariants determined? They are determined either from a more fundamental physics at the atomistic level, or by observation. The general reductionism of physics guarantees that these two will agree.

Second, what is the thermostatic state of a simple system? It is the arrangement achieved when an ensemble of atomisms dispose of their actions, by virtue of their fundamental coding, so as to 'survive' (i.e., persist in their actions).

Example 2 - An ensemble of 'simple' living atomisms of a single photosynthetic species in a watery milieu (e.g., euglena).

A. There is an intensive function that is shared by these atomisms. It is the physical temperature of the milieu. Not expressed explicitly, there are some other minor trace potentials. And there is an atmospheric potential of nitrogen and oxygen. There is in addition, a photosynthetic source, the sun (with a solar constant). But there is also an internal intensive function that is shared by these atomisms. It is a common genetic heritage. While this does not have a unique 'value' measure, the genetic apparatus is a relaxational system, an apparatus which escapement-like launches the viable system.

Thus we should make clear that our concern, in thermostatics, is only with viable systems, ones which once produced in a workshop impulsively, can persist autonomously.

B. These atomisms (a beaker in which a few were introduced and exposed to average sunlight with a given solar constant), upon near equilibrium collisional cycles (of a generation time scale) have only four summational invariants - mass, energy, tensor momentum, and number.

Atomistic properties

m e p n

C. In the local ensemble, the question is what do these transform into?

Local continuum measures (per unit volume)

ρ (gr/cm^3) u (ergs/cm^3 x generation time) {A} P (no./cm^3).

These require explanation (the purpose of this essay):

ρ - Note that density is a real summational invariant. It is basically represented by the average mass per unit atomism, averaged over the generation life time. Thus it might be given units of gr/atomism, or the like. It is actually not fixed, but depends upon the thermostatic state. It is quite possible - as with the density of a liquid - it is a rather insensitive function of state. But in general, it is a macroscopic summational invariant.

P - Population number and its conservation is 'novel' in statistical mechanics for the physicist. It is not necessarily novel to the chemist in a system involving more than one reactive species. By having bypassed systems of more than one mass species (e.g., by virtue of chemical reaction), we have avoided the richer path of exposition. But it will be more informative, theoretically, if the 'pure' single phase examples are understood first in each case (namely as the number of 'basic' summational invariants go from 3 to 4 to 5) rather than trying to learn to deal with the proliferation of more than one species or phase (involving that alternate kind of proliferation of summational invariants of independent major mass 'species'). So clearly, what emerges in a living species as a summational invariant, is the average number of atomisms, as averaged over the generational time scale. This may be measured in number/cm^3, volume/cm^3, mass/cm^3, namely all of the comparable concentration issues that the chemist faces - molal concentration, molar concentration, number concentration. But certainly there are two variables, e.g., number and mass, that are independent.

u - The reason we changed our previous molecular result from T ($= \Sigma\ 1/2\ \overline{mv^2}$) to u was to produce a clearer parity with this ensemble characteristic. We wanted the extensive property which indicated the average energetics available for exchange over a summational invariant cycle. In the molecular case, Tolman[1] has defined this with great clarity. Clearly in the living system, we have to define the internal energetics over a generation time scale - from youth to full blown maturity. Thus our variable can either be the average transit energetics per generation time per atomism, that is the power, or just the energetics so averaged.

{A} - This brings us to the action. This must come from the momentum equation, which reads

$$\rho \frac{D\bar{V}}{Dt} = \text{force} = \text{gradient of some stress}$$

The problem facing us is that somehow momentum (or specific momentum) is not quite the right variable to discuss such systems. Their action does not consist solely of cycles of translational motion and collisions.

[1] R. Tolman, The Principles of Statistical Mechanics, Oxford, 1938

We call attention to the fact that systems, as we proceed up the ladder of complexity, are marked by large internal energy tie-ups as compared to translational energy tie-ups. We have developed the basic theory elsewhere, based on Tizsa's work, that the ratio of bulk to shear viscosity, λ/μ, is a physical measure of action tied up internally, as compared to what is tied up externally as momentum[1]. The issue is the question of the relative relaxation times. The shear viscosity is related to fluctuational delays in the time that momentum is transferred from one atomistic ensemble region to another by translation. The bulk viscosity related to delays based on all other degrees of freedom (i.e., internal).

Note that every atomism is coded in the kinds of action modes that it is permitted. In the living system, this stems from a genetic code. Modes are specific diffusive (incoherent) and wave propagative (coherent) 'communications' modes.

In a little more detail, Tizsa has shown that the λ/μ ratio is basically the action tie-up - namely the ratio of the products of energy of the action mode and the time delay associated. (Literally the ratio is the excess in internal action as compared to the action in transit during the translational time scale). With a perfect equipartition of energy, $\lambda/\mu = 0$. This is found in monatomic gases. In diatomic gases, $\lambda/\mu = 1/2$ already. In more complex gases there can be appreciably higher delays. In liquids, values from one to a thousand may be found[2]. The complexity of associated liquids (e.g., water) leads to a near constant value of 3. As one approaches the plastic-solid state, or the solid state, the ratio approaches 'infinity'.

The living state is marked by very high internal action ratios. It is used in the control of internal form.[3] Thus one finds, as a result, the beginnings of complex 'memory' systems. Momentum is transformed internally and tied up for very long periods as action. Thus we basically need an action equation rather than the momentum equation.

It can be shown (e.g., as in the principle of least action for conservative systems. Where $dA = Ldt = (T-V)\,dt$, $A = \int Ldt$, $\delta A = \delta \int Ldt = 0$, expresses the principle of least action. L = Lagrange's function, T = kinetic, V = potential energy) that one can derive an action equation from the momentum equation. This involves multiple integrations. In aperiodic systems, that integration may lead to a line integral by which one

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[1] See Toward a General Science of Viable Systems and also A. Iberall, A. Schindler, Physics of Membrane Transport, GTS, 1974.

[2] See K. Herfeld, T. Litovitz, Absorption and Dispersion of Ultrasonic Waves, Academic, 1959.

[3] We have surmised, in a recent article, A. Iberall, "A Proposal for a Force Essential to Biological Organization", Persp. Bio.Med. 18, 319, 1975, that is associated with particular boundary conditions of membranes.

identifies the dynamically constrained path of motion (e.g., a constant acceleration, a slide along a wire). In a periodic system, e.g., those constrained by summational invariants, the integration should be over cycle time, here generation time. It is of great interest, but peripheral, to note in the principle of least action, that it is only that energy 'above' the potential energy that is available for activity. A little more precisely, the potential energy represents that which is bound as form, and leaves a modest region around its formal binding in which form appears as continuous springs, from which one 'potentially' can draw from. (Thereby T-V can be both positive and negative. But essentially V represents function frozen out of form from some other time scale.)

In the macroscopic living system, now, momentum appears - by virtue of genetic coding - via action modalities, as a tensor, which will at least have vestor properties. In the simplest photosynthetic systems there will be only two action modalities - grow, divide. So the action matrix can be represented as follows[1]

$$\begin{pmatrix} \tau \text{ grow}, & A \text{ grow} \\ \tau \text{ divide}, & A \text{ divide} \end{pmatrix}$$

Namely there is a time scale (e.g., fractional) for which the atomisms grow, and divide. A loose rule here would be that

$$\tau \text{ grow} + \tau \text{ divide} = \tau \text{ generation time}$$

Also there will be the action (energy x time) associated with each mode.

One should note that the action phase space is not defined any longer solely by geometric displacements and their associated momenta, but by a more complex internalized space in which energy x time is displayed and tied up.

D. The equation of state derives from the dynamic constraint that exists among the near equilibrium fluctuations of the summational invariants. Thus the physical statement is that

$$\begin{aligned} & A d\rho + B du \\ + \; & C\, d\tau \text{ grow} + D\, d\tau \text{ divide} \\ + \; & E\, dA \text{ grow} + F\, dA \text{ divide} = 0 \end{aligned}$$

The question whether this has more or less 'crystal symmetries' so that various terms vanish is a matter for more detailed exploration at the kinetic level of each system.

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[1] The biologist should and will think of the cell cycle. As in all other bulk viscosity issues, he should take the point of view of the salient energy-time phases, and not be too concerned about some dropped minor phases of information exchange.

Thus the thermostatics of this system is the arrangement achieved when an ensemble of atomisms dispose of their actions, by virtue of their genetic coding, so as to 'survive' (i.e., persist in their actions).

Example 3 - A social ensemble of humans, post Neolithic times, with settlements precipitated into place, agriculture, and technology.

We will not do this in detail - only hint sketchily at its structure.

There are two functions (besides the required physical potentials), an intensive social 'temperature' - a shared 'value' system, and an extensive social 'negentropy' - the existing rate of advance of technology, which is expressed as a productivity gain. The negentropy is regarded as a linear function of time, of man's interactional history. It had one very small slowly changing value among his hominid ancestry, it changed with modern man 40,000 years ago, and likely has not changed its acceleration since.

As a result of the genetic change 40,000 years ago, speech, a full range of abstraction, culture, were all born. Value was born. With a change in weather and precipitation into place with agriculture 12,000 years ago, a new thermodynamic variable - value-in-trade - emerged. This is related to nonlinear convection among settlements. A new set of thermostatic constraints emerges, e.g., two class societies, the populace and the elite.

Thus this system has some physical potentials - e.g., temperature, material atmosphere, ecology which presents an ingestable biomass source of energy, and in the interior phase space of 'mind' (i.e., the physical energetic dimensions of brain), a social value function T, and a rate of change of technological productivity - S. It then has a minimum of 5 summational invariants - body mass, average lifetime energetics, family population density, an action tensor involving 20 modalities (the class of mammals may only involve 9), and value-in-trade. The relevant dynamic phase space is mixed, partly external, partly internal. But these relations hold for the distribution functions - the populace and the elite.

And as with two phase simple substances, there are constraints between these two phases.

And the equation of state. It is the arrangement achieved when an ensemble of such atomisms dispose of their actions, by virtue of their genetic and epigenetic coding (learning) so as to 'survive' (i.e., persist in their actions).

It is this thermostatic description that we shall attempt to achieve for society.

On Two Distribution Function Societies

We have no trouble, although it may involve very difficult physics, to trace the stability issues that govern the appearance of two phases (or two atomistic species). For example, if we take a volume of atomisms (e.g., neon) at a fixed wall temperature, with a sparse collection, we note a near ideal gas single distribution arrangement. But as we keep adding atomisms, we finally come to a number wherein a cluster will appear. In our model, this is a cluster, a cell, of about 20 atomisms. Which 20? Any 20. Any that may in fact fluctuate from region to region. Temporary liquid phase fluctuating condensations have begun.

The point is that it is not difficult to surmise, for stability criteria, that two density distributions each with their energetics can coexist and still share some common measures, e.g., temperature and pressure.

Now we must convince the reader that post Neolithic societies have clusters of the rulers (of people energetics) and the ruled, and further that this cluster hasn't depended on the political system. Now clearly, the reader can sense this with pharoahs and kings, and barons and dictators, but he may question whether this is true in a democracy, or in our democracy.

We can begin to examine the problem as we might detect its form in income distribution.

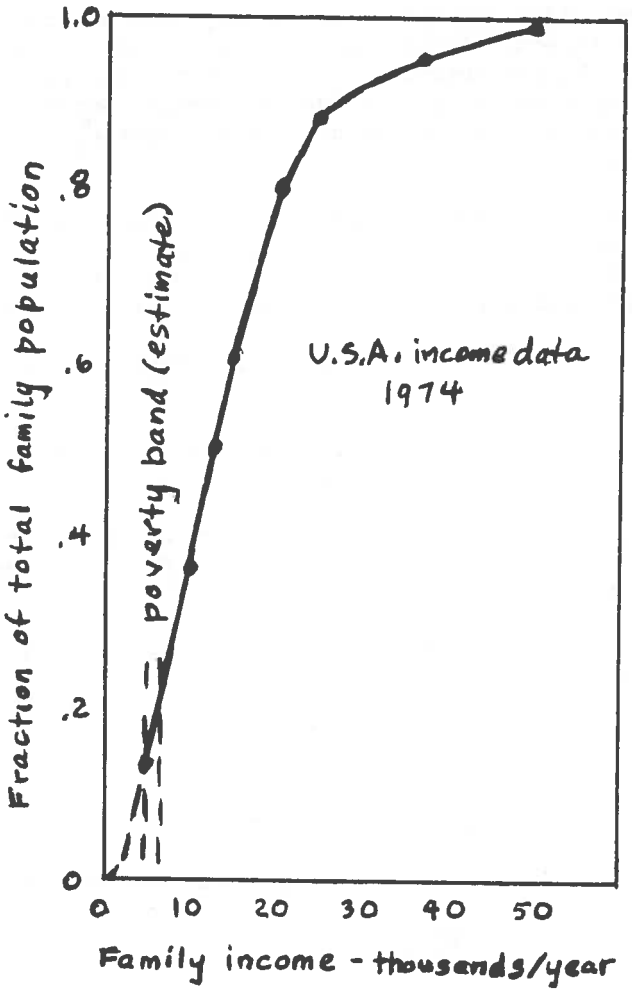
The issue polarizes in the work of two different scientific outlooks. On one hand one may examine the Lorenz curves of income in Samuelson's Economics, 1970 (Chapter 6), and a much too casual dismissal of 'Pareto's Law'. On the other hand one may examine the arguments in G. Kolko, Wealth and Power in America, Praeger, 1962. Also see the review, A. Hacker, "What Rules America?", N.Y. Rev. Books,(p.9) May 1, 1975. The issues we do not wish to debate are concerned with social or cultural irrelevancies. We do want to debate power over human action, but even such an inquiry would lead us into some deep crevasses. So we will confine ourselves, imperfectly, to family income.

Some very recent (Census Bureau data covering 1974) data are given by G. Wills, "Raise Taxes and Start a Revolution", in a newspaper editorial (Phila. Inquirer, Aug. 15, 1975). There data are:

55.7×10^6 families (100%)

Poverty line - $5,000 per year (for non-farm family of four).

7.3×10^6	families	(13.1%)	earned less than $5,000
20.0×10^6		(35.8%)	10,000
27.8×10^6		(50 %)	12,840
33.6×10^6		(60.2%)	15,000
44.6×10^6		(80 %)	20,445
49.4×10^6		(88.5%)	25,000
52.8×10^6		(95 %)	31,948
55.0×10^6		(98.7%)	50,000



We will quarrel with only one number. From a variety of sources - social service required retirement income for a couple of $4,200 for a low income budget, or $6,300 for an intermediate income budget - we would surmise that the poverty line is closer to $7,000 than $5,000. In any case, our remarks will take both estimates into account.

Before moving on to discussion, it is necessary that the content of three different curves be understood. The first curve is a plot of the cumulated fractional national income I (0 to 100% of total national income) versus cumulated fractional number of families P (0 to 100%), a Lorenz curve.[1] This curve is misleading. Its cumulative nature disguises the distribution function. Thus a more interesting curve is its derivative. That can be shown to be the curve

[1]It is this curve which Samuelson (Economics) discusses at considerable length in his Chapter 6, "Incomes and Living Standard". It is this curve which we will attack as misleading.

we presented before, except for a scale factor. The immediate slope of the Lorenz curve dI/dP, is the annual family income normalized to the average family income. It is that curve which we will suggest already shows that the population is made up of two distributions. (In our previous curve we did not divide by average family income). It is this curve that we suggest has not changed markedly throughout the past 10,000 years.

The methodological issues involved in determining the distribution function warrant some discussion in their own right. The sole use of a Lorenz income - population curve tends to obscure the issues. Our argument can be followed with respect to the following figure.

Let us imagine a variable which has a distribution function associated with it.

The distribution function, by definition, is how a metric property is distributed among the ensemble population.

We have indicated an idealized distribution in the intensity p of a property, family income/average family income, i/i_o. We have indicated a minimum i_{min} and maximum i_{max} income.

The integrated distribution as summed over the cumulative population P is shown following. Thus

$$P = \int_o^{i/i_o} p \; di/i_o$$

$$I = \int_o^{i \; max/i_o} p \; di/i_o$$

The latter is the normalizing relation for cumulative population, and

$$\frac{dP}{d \; i/i_o} = p$$

is the definition of income intensity.

The average family income i_o is defined by

$$i_o = \frac{\int_o^1 i \; dP}{\int_o^1 dP} = i \; dP$$

it is the average height under the i/i_o curve. Thus it is useful to examine the curve on its side. Then the area under the curve (hatched one way) is equal to the area under the mean height (hatched the other way)

Thus the first curve is the derivative of the second.

If now we cumulate over the property i/i_o, we get a third 'phase'

diagram. This will be cumulative income I. Thus this curve, P vs. I is the Lorenz curve.

$$I = \int_o^P \frac{i}{i_o}\, dP$$

$$1 = \int_o^{\infty P} \frac{i}{i_o}\, dP$$

$$\frac{dI}{dp} = \frac{i}{i_o}, \quad \frac{d^2I}{dP^2} = \frac{d\ i/i_o}{dP} = \frac{1}{p}$$

Thus a 'fourth' quadrant curve can present income intensity p (the curvature d^2I/dP^2) against P, also alternately i/p vs. P. Thus either the first figure or the fourth figure presents the distribution function. And generally the first is the most transparent.

Note that the distribution function is the second derivative of the Lorenz income-population curve. As such, the Lorenz curve masks the population details.

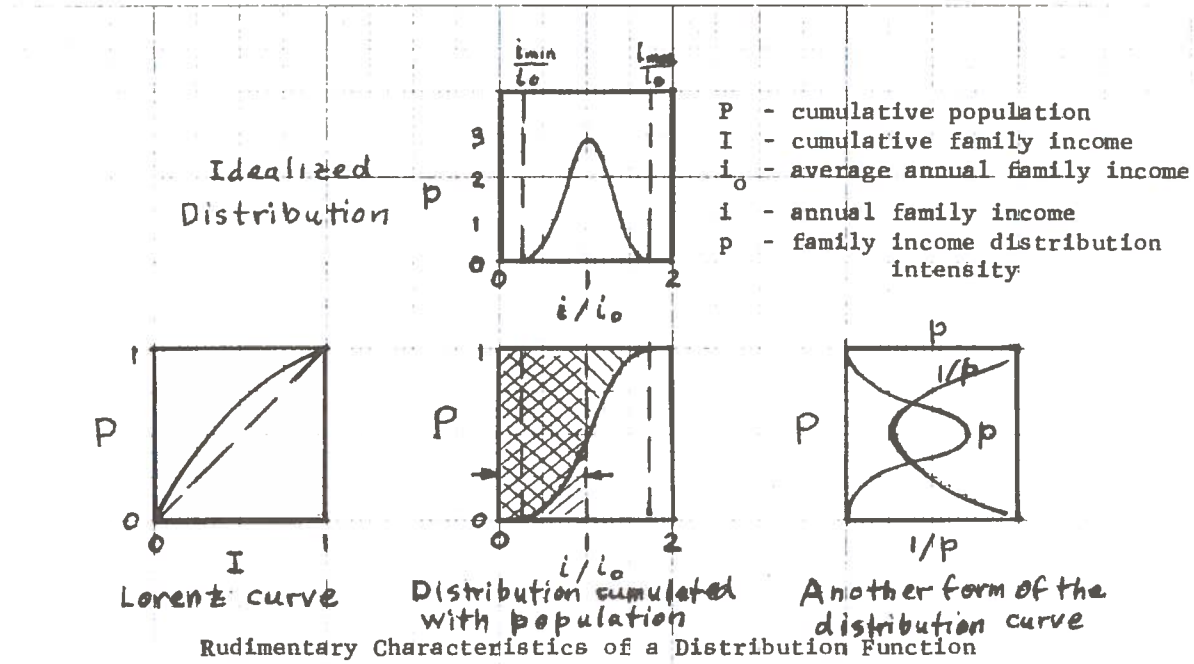
One can imagine various cumulative distribution functions and note their relation to the Lorenz curve. A square top distribution function is shown leading to a parabolic Lorenz curve. A uniform income is shown leading to a 'monochromatic' distribution function.

Before moving on to discussion, it is desirable, as in the days of physics, prior to Planck, to at least have the distribution function in mind which describes any 'modern' society. Thus we will combine the previous data with some tail end data (Hacker, "What Rules America") in a dimensionless generalized plot.

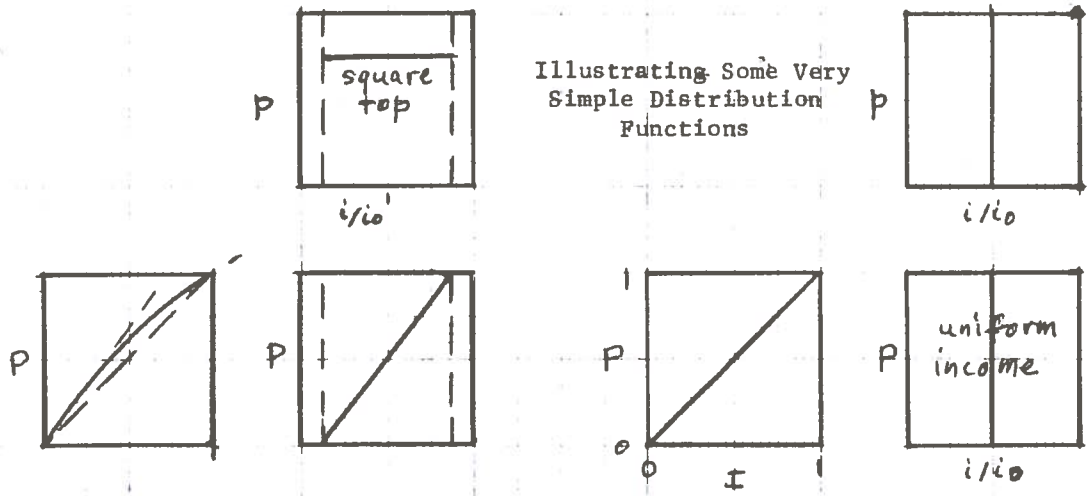
The character of the actual income distributions is shown below. It is found to be quite crowded near the axis. Notice that it has an extremely long tail, e.g., for incomes above i/io = 2. Thus the character of the tail of the distribution function, or the existence of a second lobe cannot be so detected.

That situation is not unique in statistics or statistical mechanics. The test that has to be made is simple. The cumulative scale is expanded and a logarithmic derivative is presented instead.

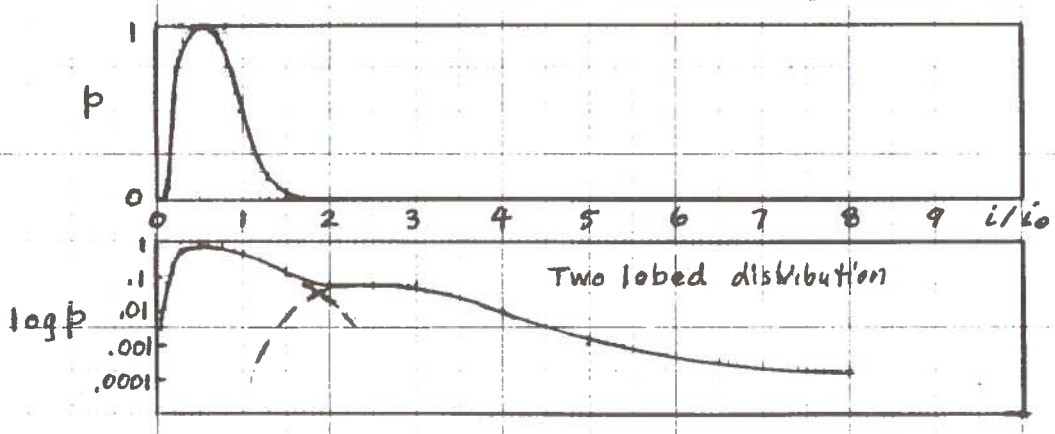
So if we use the tail end data and expand the intensity function p logarithmically we get the bottom curve.



Rudimentary Characteristics of a Distribution Function



The Character of the Real Distribution Function



The cumulative annual family income distribution (lower figure) quite clearly suggests a mixture of two populations, rather than the smooth uniformly changing monotonic Lorenz curve. Clearly the notion may be attributed to Pareto earlier. So we will make no claims for its discovery. The lower panel in fact shows an estimate of the two distribution functions. The rules of decomposition (involving a smooth roll-off of both tails while properly summing) allow very little discretion. Thus qualitatively and fairly quantitatively, we have indicated the decomposition. There is little doubt of a higher income 'elite' structure, although a proof will not be explored that these elite are in fact also the power elite who control people energy. We likely join a considerable list of persons who have discovered this point. Although we would like to insist that, once thus expressed, it is quite clear to engineer or physical scientist that this point can not be buried.

But our problem is to be scientists, not radical or reactionary economists, anthropologists, sociologists, etc. We have both a tentative thermodynamic theory and now such experimental data that in fact requires and illustrates a two class society. And our premises is that similar distributions hold in feudalism, capitalism, socialism, communism, etc., as long as the notion of fixed settlements and value-in-trade existed.

Thus far we have only presented a casual look at family income for one year for the U.S.A. and have made some assertions as to its character. For a more extensive amount of data, we can examine Kolko.[1]

Kolko presents Lorenz curve data, USA 1910-1959. These data indicate essentially no difference in the character of the distribution functions. Namely in some basic ways, the distributions are stationary. Whether one would or would not surmise well defined numeric parameters associated with these distributions, as Pareto began to try to associate, is a matter for further exploration.

But at this point, even if premature, it pays to look ahead toward some likely implications in these data. They seem to both serve and deny the claims of both left wing social scientist and right wing social scientist. We would assert these tentative notions as follows:

1. There is quite a large middle class that is supported at levels appreciably above subsistence in this industrialized nation (approximately two-fold, i.e., $13,000 as compared to $6,500).

2. But if Roosevelt stated that one third of the nation is ill-fed, ill-clothed, and ill-housed, one surmises that World War II cut the fraction down to 1/6-1/5th. One finds the same level, 1/6-1/5th of the population remains so. The magnificent vision of Johnson of attempting to eradicate poverty and create a great society did not work. Thus, within existing theories, one cannot say that a clear idea of what determines the dynamics of a society exists. Clearly the two

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[1] G. Kolko, Wealth and Power in America, Praeger, N.Y., 1962.

extremes - radical and conservative economists and social scientists - will say "We told you so" for very different reasons, but as objective scientists we are not convinced that their systems' comprehension is compelling. And certainly, economists' performance in the past few years provides no conviction to any scientist (except perhaps to highly defensive economists) that economists really understand social dynamics. So we literally are back at square one.

3. The rich power elite manage to retain their holdings. This does not mean that there is no turnover in the class in very few generations. Darlington's history of outbreeding and inbreeding in the control of leadership makes the turnover notion compelling.

4. The total extent of the elite class is likely broader than a narrow 2% impulse,. At its base it may cover 10% of the families. In income, the cross-over point with the upper income populace occurs at about $32,000 per year of family income. Namely there are both elites and non elites at this income level.

5. But that notion is somewhat misleading. The populace family income has a mean deviation range from about $5000 to about $18,000; the elite family income has a mean deviation range of about $35,000 to $75,000. The mean core of the elite population lies within the top 4% of the family population. Thus the original estimate of a 2% flat-top impulse distribution is still essentially valid. On the basis of considerable study, it may be found that the impulse width is more like 3%, but such issues at present would only be quibbles.

6. But still, it is remarkable how broad the populace distribution is. Namely it is nearly a flat top distribution covering 70% of the population. Thus most of the notion of the American dream is in fact true (i.e., 90-20 = 70%).

7. One can surmise, under these conditions, why many reformers would believe that it really wouldn't take much change in operating policy to bring the lowest fraction 'into solution'. (an unintended pun). And that such changes could be done without any great deformation of the capitalistic system. Of course radicals say that it cannot occur without a profound restructuring of society. And extreme conservatives believe that it cannot be modified without a significant degradation of society for all, rich and poor. Capitalism they believe, has achieved the optimum solution.

8. Our view, at this point, is that the radical are wrong, because even the profound restructurings have not changed the distribution character. And the extreme conservatives are wrong, because other systems, e.g., mixed systems, have achieved equal or better equity distributions. Further optimality has nothing to do with the capitalistic choice. Capitalism just happened to fit very well the past two centuries mechanistic explosion of technology. On the other hand to counter both extremes, we believe that the elites are essential. They literally drag the level of the populace up by their bootstraps, through their amplifying energetics. This makes us not one less whit populist. It is just the ques-

tion of finding a set of equitable rules. We are personally satisfied with a capitalism (or any other system) if it includes a value function other than bugger thy neighbor. Here we accept the morality basis of the major religions, but only when they do not wish to dominate or rule others.

9. There is absolutely no way to discuss a social physics without a value function. Thus even if we are complete physical reductionists, and thereby completely mechanistic, those mechanisms are not Cartesian gears, but the abstractions and idealisms that run mechanistically through the human brain. Thus, no Marxian dialectician would accept our notions.

10. Why are all of these apparent philosophic, esoteric issues being brought forth? Because the question we face in our nation, as do all other nations, exacerbated now beyond most earlier times, is the human prospect and survival. Can such favorable distribution funnctions continue? Can they be slightly improved? (Namely to bring the 15-20% into the fold by some other means than welfare or genocide.) Will there be a deterioration of the distribution? Or are all our efforts at dealing with such issues in vain? We do not believe the latter. That is why our scientific concern. Man - Prometheus-like - can do something about his destiny in a physical thermodynamic sense. But we insist that it must be in that sense. We do not have to enumerate all of the harbingers that suggest that perhaps things are getting worse, and that nothing can be done.

Of course, we will suggest that the whole dynamic issue of social physics is to indicate how this and various correlated variables and distributions in fact do vary around a central stationary distribution which makes up the control thermostatics of society. Thus the specific variation from epoch to epoch, country to country, political system to political system, technology to technology is a variable distribution. Its long term central character is not. At this time, we are trying to get a primitive glimmer of its major characteristics. The Lorenz curve does not give it. The annual income distribution begins to. It is only if we take the derivative once more that we find the distribution function for the two class society.

It is some of the stationary character of these three curves that we wish to expose.

So we wish first to achieve a parity for our Lorenz curves for the USA for some time. Thus we start from our earlier 1974 data.

We required a plot of family income per average family income (rather than absolute family income) versus fraction (or percentage) of the number of families. For the 'current' 1974 data, previously plotted, we need to determine the average family income. We have based that average on the following: an estimated 1974 GNP of $1.3 trillion, and a National Incomes of about $1.06 trillion. Thus with 55.6×10^6 families, an average income of $19,000 is obtained. When compared with the median income of $12,800, we find that the nominal elite take is

about 47-48% of the total national income. This is essentially similar to our a priori estimate that the elite take 1/2 off the top. With current incomes (We base our estimate on the previous figure, by estimating the total income for under 90% of the population. If one shifts the mean income down to about $11,000 for 45% of the population, then 11,000 (1-f)/19,000 permits one to estimate the populace fraction of the total national income. This equals about 52% for a 10% elite.) The elite would be regarded as 10-11% of the total population. This seems reasonable as a 'range' wherein its standard deviation metric is about 1/3rd or 3%.

The Kolko data[1] (his Table 1), 1910-1959, are national income before taxes for each income tenth. (The effect of taxes on the distribution is negligible.). To normalize these data, we have cumulated the percentages, plotted them on equal scales. The data are then presented in the following graph.

For the 1974 data, we have integrated the area of the previous family income curve to cumulate it into a Lorenz curve. One notes that except for the wobbling with time, a rather uniform band spans the incomes distribution in the U.S.A. 1910-1974. The following table indicates its range.

Percentage of family population - P	Percentage of the cumulative national income - I
20	6 ± 2
40	16 ± 4
60	31 ± 3
80	52 ± 4
90	65 ± 5
95	75 ± 7
(100)	(100)

Now for some properties of the two class distribution. If one examines first the cross-over point of that percentage of the population at which the average income is reached (unity slope of the Lorenz curve), it has oscillated from 60 to 80% of the population.

The average income is higher than the median income by a ratio of about 4 to 3 (i.e., 1 to .70-78, average 0.75). The low end of the populace income is about 1/4 of the average family income, and the high end of the populace income (extrapolated from about 80% of the population)

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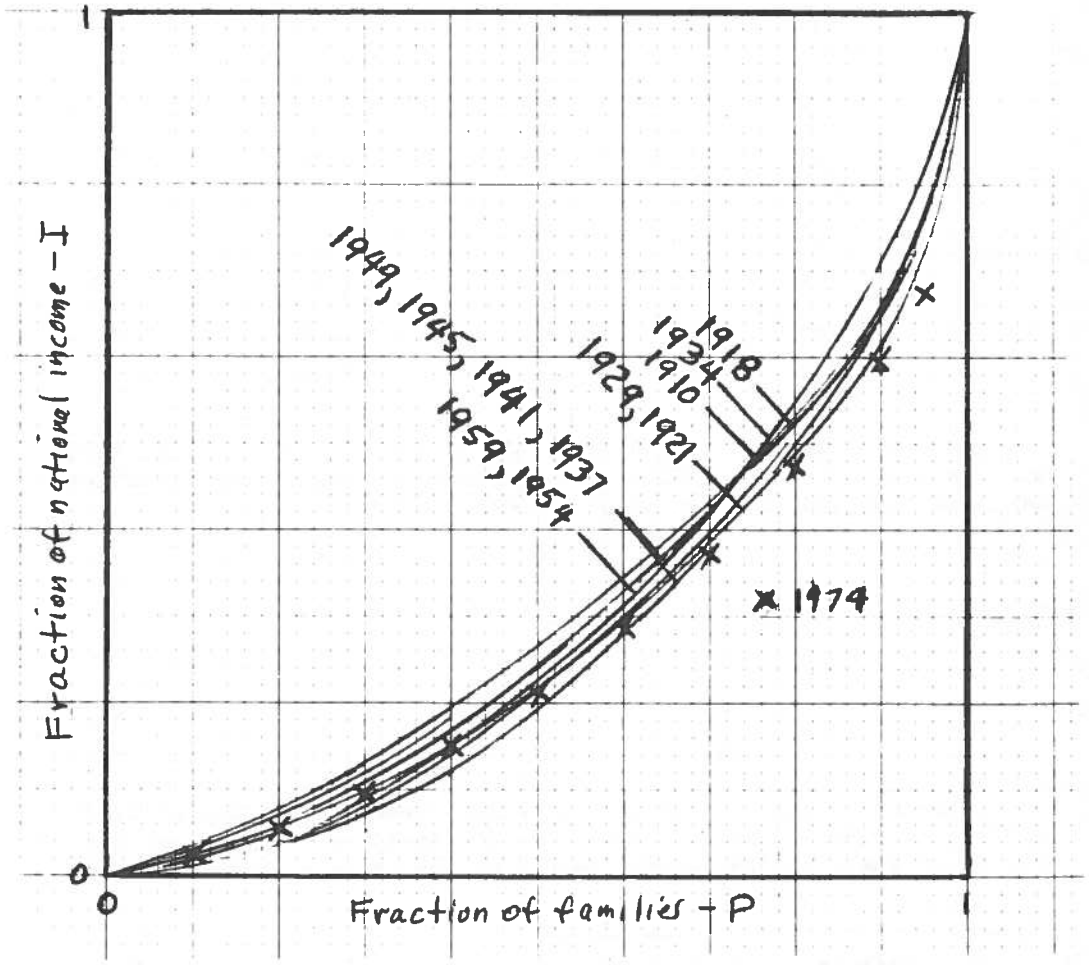
[1] G. Kolko, Wealth and Power in America, Praeger, 1962.

is about 1.3-1.5 times the average income.

It is our assumption that the low end (1/4th of the average income) is approximately the subsistence margin for a family in each society. If the populace distribution were uniform (e.g., linear), then the distribution function (the slope, e.g., 1.3-0.25) would be basically approximately 1.



And in fact, if the Kolko data are averaged (e.g., in the following table,

Fraction of family population receiving less than the stated annual income[1] - P	Annual family income / Average annual family income (average ± average deviation 1910-1959) - $\frac{i}{i_o}$
.05	.13 ± .04
.15	.32
.25	.48
.35	.61 ± .02
.45	.74
.55	.87
.65	1.02
.75	1.19 ± .08
.86	1.47 ± .10
.975	3.18 ± .25

We can estimate the tail from data in the Hacker[1] article, "What Rules America?". From 1972 income tax data for high income families, which we have faired into our 1910-1959, 1974 data

P	i/i_o
.988	4
.998	8
.9996	16
.99992	32

The last figure is for recent family incomes above one million dollars, an income achieved by about 1000 families.) one finds a distribution function (the slope) hardly different from what we showed

[1]Kolko's data are national income per tenth population, i.e., the chord rather than the tangent to the Lorenz curve. For the low slope change intervals this is very nearly the mean of the interval. We have taken the general character of the Lorenz curve, at the higher slopes, to estimate where the tangent might be in the interval, i.e., 0.86 rather than 0.85, 0.985 rather than 0.95.

[2]A. Hacker, "What Rules America?", N.Y. Rev. Books, p. 9, May 1, 1975.

before. Namely there is a broad distribution function ($dP/di/i_o$) of about unity value. This persists out to 70% of the families, and then drops toward zero at about 90% of the population.

The cross-over point with the elite occurs at about 95%, with the 'foothills' of the elite distribution function rises very rapidly for the elite population that mix with the populace within the 80-90 percentile. The top 15% of the population is nearly all elite, but the real elite are to be found in the upper 5% of the family population. Namely an impulse distribution whose double integration would lead to the Lorenz curve tail would be about 3% wide.

As we stated, contrary to the notions of radical economists, it is our premise that these figures and ratios have likely never changed in any mature political system.

As a personal interpolated remark, we do not really find these numbers as being highly unbalanced. From that point of view we are more in accord with Samuelson's spirit. But we insist upon a different theoretical base for its comprehension. Classical economic attempts to close its system within one summational invariant compartment - value-in-trade - by assuming an optimization function. We do not accept that notion, and instead must find closure with 5 summational invariants.

Our basic social critique - expressed early in our research program as a pure intuition - is that the social problem is to run the system wherein that significant percentage (e.g., 15-30%) of the population that are at the margin of survival are satisfied with their status, and to devise a regulatory scheme where elite status does not become hereditarily inbred, where instead elite status is a reward for social aggressiveness, and removable when that merit ceases. Social aggressiveness can either be in act or in thought. The problem in all social systems heretofore - capitalist, socialist, communist, feudal, etc. - is that the elite 'quickly' want to reward their progeny, confusing social and individual goals. It is too premature for us to offer answers, but at least we may offer our preliminary perception of the basic questions.

And it is not our goal to keep the 'poorest' fraction of society poor. It is simply a recognition that society must run at the survival margin in the long run. What value system the society accepts arises from the dual interaction of the populace and elite. How 'comfortable' the survival margin is, depends on the operational status within the ecological bounds and the state of technology.

Now of course these numbers fluctuate. The thermostatic state emerges as a dynamic balance among the atomisms. In the fluctuations, it is quite possible that one end of the distribution or the other (e.g., the poor, or the elite) or even the middle scream out for attention. It is not yet clear to us what the algorithm of a perception of injustice makes these groups yell. Our piece[1] suggests that groups yell

[1] A. Iberall, "Introducing Sompe Operational Characteristics of Mind - The Human Outlook and the Dynamics of Society", J. Dyn.Syst.,Meas.,Control, p.285, Dec. 1972.

when they perceive the past to be better than the present. A check point is the current status of the British elite. They are grousing, and labor begrudges them their status,[1] under the condition where the upper 10% of the population controls 25% of the national income, the same as they did in 1949. But both sides consider the situation then better than now. In real perception (see previous figure) their status is not better than American elite systems. Thus we may be on the right track of the operative algorithm. So we pass on.

Namely we must pass on to the other summational invariants. For example, why should the elite impulse represent 3% of the population? We offer a purely 'idealistic' notion for this, namely one that stems from the character of the human mind. For this we shall attempt to pull together a large number of observational bits and pieces.

We have found experimentally, on the basis of a large amount of experience, that intellectual aggressiveness can only be tolerated by managerial elites at most of the order of 1 day a month.

We have noted that primate leadership is of the order of 1 leader per 10-20; and more like 1 per 20-50 in humans.

We note that both, intellectual and physical aggressiveness ('pushiness') is rare, and occurs in about such ratios as a few persons per hundred. Note that it has more commonly been found among males.

We note that aggressiveness increases with social density among primates.

We note that the Biblical effort to establish one day in seven as a Sabbath to be marked by fully positive actions (of withdrawing from ordinary tasks and devoting it to worship) has only succeeded marginally in history. Rather the numbers of intense 'holy days' is more nearly of magnitude 10 per year.

We note that on television, the efforts to occupy as many as 10 minutes out of each hour with advertising is quite offensive to most whereas 1-2 minutes per hour is tolerated almost without perception.

We note that 2 weeks of holiday per year is a fun thing, whereas much longer made-up activities require a large degree of discipline.

All of these and many more observations tend to support the notion that aggressiveness in the population - arising as direction of the operational modality from the human mind - is a part time occupation in an ergodic sense. On conversely, there are few in the population who can sustain it. And the issue occurs at all time scales - hours, days, weeks, months, years, decades, generations.

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[1] R. Semple, "British Labor Confronts a Labor Party Prime Minister", N.Y. Times, Sec. E, 3, Aug. 24, 1975, Report of a Royal Commission, Aug. 1974, Union leader's perception.

"Human nature" thus acts to select the amount of elite (high mobilization of other people-energy) activity in human societies.

For this to be a scientific 'law', it must be negatable and testable as an experimental proposition.

Let us make clear what the test is. It is, in part only, tested by the pre Neolithic principle (i.e., pre value-in-trade) in which a random selection of individuals of different size groups are tossed into average temperature zone ecologies, and one notes the conditions of survivorship under nomadic conditions. How large are the groups that succeed and persist after a few generations? How large is their leadership?

The real test, with value-in-trade added, is the tossing together of a random selection of individuals into an existing constellation of trading centers, and again one notes the conditions of survivorship within those societies. How large are the groups that succeed and persist after a few generations, if the experiment were done in the past, now, or in the future? How large is the elite leadership? What is the distribution of 'family' income and wealth after a number of generations? We would surmise that the history of settlements in the USA and other regions of the world could furnish experimental tests of the thesis.

Having established some formal premise about income distribution, vaguely at this point related to value-in-trade via the survival margin, we can proceed further in our thermostatic modelling.

Now excess income, beyond a few times marginal income, is of only limited use. Namely the results of value-in-trade, differing from external thermodynamic variables, can only be used for limited purposes. One cannot gorge one's self with more than 2-3 times normal metabolic requirements; one does not fulfill any useful criteria for living by having available an indefinitely large number of shelters. The number of personal services that can be performed on or for one's person is limited. One is loosely aware of the large sybaritic excesses of many civilizations - the excesses of the ancien regime, the jet set, Rome in its days of decadence, etc. But, conversely, one is aware that the excesses are and have been confined to a small fraction of the population. Two things are clear - the notions of such excesses stem only from the human mind, but they are characteristic of only a limited fraction of the population. And when one grasps that equilibrium does not begin in less than 3 generations, and one doesn't move toward near equilibrium in less than 1 generation, it is clear that such ideas can only be idiosyncratically maintained by a small fraction of the population.

Thus it is necessary, in civilizations with any survival margin, that the excess income be put to social use. It must be put into motion.

This does not mean that all excess above the margin of survival is 'gainfully' employed. It means that there is a characteristic set-aside for useful investment, and one for excessive consumption (excessive above survivorship). While this may fluctuate, from time to time, place to place, era to era, ecology to ecology, nevertheless there is a 'thermostatic' distribution characteristic of the human mental construct.

But the important thing to note, whether income is used for 'productive' produce directly in the thermodynamic chain, or 'nonproductive' produce that appears not to be directly in the chain, nevertheless two basic ideas are involved. Other people's energy is involved; and technology is used as a gain factor on other people's energy. A third notion that should be mentioned is that instead of using only renewable resources as do most other living systems, man also feeds his chain by the use of nonrenewable resources. Thus witness one ultimate reason for the fall of empires, if naught else.

When equilibrium is achieved, the excess income has to be used each year for investment into the operational chain. One may argue with how long the excess is built up, year by year, before near equilibrium is achieved, but ultimately it is built up. The nominal time constant may lie in the range of one to a few generations. Namely approximately each generation, each new family undergoes some growth of income trajectory and net growth of 'wealth'. A very small number of families may in fact show sustained growth for a number of generations (e.g., even as large as 10), but as Pareto indicated, a penny invested at compound interest does not grow indefinitely.[1] Inbreeding, outbreeding, predation, revolution, etc., ultimately take their toll. So in the elementary model, there is little growth in the relative distributions beyond generation time. Thus systems' dynamics - war to war, or generation to generation - are satisfactorily near equilibrium irreversible thermodynamic.

The nominal fixity of the income distribution means that there is approximately a fixed ratio of families that 'serve' (i.e., work for) the elite and thereby serve themselves. We can dispose of one major variable by pointing out that since the elite come ultimately from the populace, their perception of a family size is the same as the populaces. Except for fluctuations, the elite family is the same size as the populace's. What is not fixed is the size of either family.

What is involved in the size of the family? And, a related question, what is the population concentration (of families) bound to a particular earth region (e.g., city, or nation).

In post-Neolithic hunting-gathering times, the aggregate nomadic group had to be large enough to exist at the margin of survival. Thus range and size and action modalities and energetics was essentially cast at a near equilibrium by that constraint. Human mobility and the ecological boundary conditions tended to force the range. The size of the group (shall this be referred to as 'horde' or an extended family, distinguished from what is imagined later to become a tribe?) is governed by some specific 'perception'[2] of a carrying capacity within that ecological niche (At least this seems to be so for all other species, in an ecology, in competition with the survival of other species). Population size, then, except for fluctuations and a slow growth with changing technology,

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[1] Namely there are always thermodynamically degradative processes that break the intolerable Malthusian - first order kinetic growth status.

[2] The notion of 'perception' is used, because often deus ex machinas, arranging things from outside, can show means of sustaining higher population levels than arrived at naturally. This, of course, may be at the expense of many other species in the region.

may remain near constant. At least this is the story we would infer as more material becomes available from other primates (e.g., chimpanzee, gorilla, baboon) to complement human ethnographic studies.

Post-Neolithic, with constellations of fixed settlements and value-in-trade, molecularities of interacting families developed. The family size was largely dominated, as was the earlier nomadic group by what it took to make a living from the land.

The particular character of the familial ties depended on ecology and technology to a large extent. It is not our intent to invent a false primer for ethnography. That story of development is not yet complete. It is for anthropological experts to tell. But throughout a history of fixed settlements, the family has been a near equilibrium unit - namely it was responsible for essentially its total balance, economic included. Thus its ingathered size was proportional to that task.

But note the paradox. Except for the issue of viable survivorship (e.g., avoiding excessive childbirth mortality), any family size beyond replacement size implies a growth in population. And for human population, this means a saturation of 'family' size (namely what blood relatives are included in the family may differ in different ages) and therefore an expanded growth outward.

In pre Neolithic time, the nomadic expansion was very small. In post Neolithic times, the very method of living implied an expansion. So starting from 10,000 years ago, we have faced that kind of expansion, a population doubling for some number of generations.

> The subject of human population requires some discussion. While the human social system is always near thermodynamic equilibrium locally (except for revolutions), this does not mean that there is no growth in the field system. And in fact, the human population has always been growing. There are at least two systems reasons. One, that which made man and his hominids tool using, represented an epigenetic growth in technological capability. That has been associated with a productivity gain which has made increased population feasible. Second, changing ecological factors, e.g., the trying period of ice ages which put genetic pressure on man's hominid ancestors and how he would adapt to his environment,apparently increased his success in the ecological chain. And with the last retreat of the ice age, man has become particularly advantaged. Thus an increase 'Malthusian' growth.
>
> It has become the conventional wisdom that the fantastic growth of human population of the past 200 years is associated with the industrial revolution - in a period in which the productivity gains due to technology increased very significantly. It is our thesis - which is likely shared by an increasing number of people who reflect on the problem - that that exceptional growth period has come to an end. Thus what we are confronted with now are the pains of adjusting to a very large 'middle years' growth as man tries to learn how to bring the entire system into a closer to equilibrium operation.
>
> Specifically, our perception of the problem is that young people sense that they are economically superfluous, and that in fact they

are economically superfluous. This is particularly true in the well-off middle class family. Thus there immediately is major reason for conflict between the generations.

We (as individuals) are on the side of the young, and we over-produced in number of children. But that is irrelevant.

What is relevant is the need for very careful steering of the social boat in the transition to a lowered population. The process will take place whether we steer carefully or carelessly. History provides easy enumeration of the methods - pestilence, famine, war, turmoil, are all easily come by. The more difficult question - are there other means? The function of a social thermodynamics is to provide some dynamic constraints which can permit achieving a semi-rational relaxation.

For those who wonder whether this is mostly metaphor, we can at least point out one major factor which lies behind the real modelling of the processes. In Neolithic times, the life expectancy was perhaps 18 years; in post-Neolithic times, perhaps up to 1600, the life expectancy was approximately 30 years.[1] The mortality curves, from which the life expectancy can be estimate, now approaches a square top out to peak life span at the order of 90 years, more so than ever before.

For example, let us provide some recent life expectancy data[2] on 102 countries.

Current Distribution of Life Expectancy Experience

Life Expectancy Range[3]	No. of countries	Per capita income median	± average deviation
25 - 29.9	1	75	± -
30 - 34.9	2	85	± 20
35 - 39.9	14	105	± 60
40 - 44.9	16	120	± 55[4]
45 - 49.9	11	200	± 125
50 - 54.9	15	330	± 170[4]
55 - 59.9	5	340	± 50
60 - 64.9	5	430	± 170
65 - 69.9	6	705	± 200
70 - 74.9	17[x]	2010	± 1080
75 - 79.9	10	4100	± 1020
	102		

[1] A Comfort, The Process of Aging, Signet, Science Books, N.Y., 1964.

[2] "National Wealth and Its Effects", N.Y. Times, Sec.E, p.3, Sept.28,1975.

[3] For the longest living sex generally female; generally average for all races, except in one case (marked by x).

[4] One country with extreme (distorting) per capita income was eliminated (oil producers in transition).

The median of each interval was chosen to minimize a few excessively distorting countries. It is rather remarkable how smooth the median curve is, and the average deviation - clipping a few transition countries - is not inordinately wide. Also it is clear that the curve tends to be asymptotic to the 90 year life span of humans. It is unfortunate that the data are only presented as per capita rather than as family income. Thus our conclusions may be somewhat distorted.

But we can visualize the world picture as follows: Poor countries still live at the margin of survival of Neolithic times. The world annual per capita income required for that level is about $100 per year. There is a broad range in life expectancy - from 30 to 60 years - that one pays for at such low level incomes, e.g., below $400-500 per capita per year. Conversely, the life expectancy rises from 65 to 80 years in the per capita income range of $500 to $5000 per year.

The association of high value-in-trade magnitudes with high industrial technology and high life expectancy poses one sort of control problem - including population control - for those industrial-agricultural nations. The association of low value-in-trade magnitudes with low industrial technology and low life expectancy but large population density poses another sort of control problem. The low technology, low population countries pose still another control problem.

The point is that thermodynamic instability issues among the nations of the world are not all of one kind. There are lags, among nations, of up to 5000 years in socio-technological development. (Just as there are differences in evolution among living species of up to 10^8 years). It is only the potentials they all have to draw from that are the same.

Thus even if we concentrate on 'our' problems, we must be conscious of the larger currently interacting world.

In a dilute ecology, that growth hardly affected the character of the dynamics. Urban settlements would grow. Outsiders would ingather. Insiders would 'swarm' and move farther out. New settlements would form. Thus the first tendency toward thermodynamic equilibrium was for this kind of open 'isothermal' environment.

But in time the space fills up. For urban humans, this process took about 5000-10,000 years (i.e., from 8000 B.C. to 3000 B.C. - 1000 A.D.). That entire period becomes filled with weak interactions. Civilization centers rise and fall. They nucleate, attract a considerable population, undertake conquest of surrounding lands, overextend themselves, run out of the sustaining energetics. Then some other center nucleates.

But through either kind of systems! response, the family size isn't affected much by the large scale systems' dynamics. For example, if a nation has a ruler, his needs are taken care of by families producing another child (or two) as soldier, or servant. The basic relative number of elite families and populace families doesn't change. It is only technology (and ecology) in the main which governs the size of the family.

What does the elite do with his surplus income? (Beyond the increased cost

for high style of living). He invests it in productive tools - e.g., land, machines, plants.

Suppose first there is a 'primitive' technology. What constitutes 'primitive'? If we examine structures and processes back to 6000-8000 B.C. (e.g., Catal Huyuk), we find a large degree of organized public structure in the settlements. A town of 6000 in 6000 B.C., covering 30 acres indicates a large amount of organized effort, albeit 'primitive'. Certainly the kind of complex structures that one finds by 4500 to 3000 B.C. in the Near East shows a fantastic amount of organized effort.

Thus clearly, even in the periods of 8000-6000, 6000-4000, 4000-2000 B.C., even with the 'primitive' technologics of human settlements, a man could produce more output than was required for his own survivorship. Clearly the surplus daily energy, with that technology, was available to build up a wealth of social savings.

Why would the individual not invest his own surplus in building up his wealth? That remains the great mystery in which man indicates that he is still a biological species like all others. Most people have no preparation for dealing with circularly causal systems.[1]

Causality, in aperiodic phenomena, relates A and B via their sequential occurrence within a short enough time frame. But in circularly causal systems - generally involving fast (e.g., escapement) and slow (e.g., inertial) processing - A 'causes' B and then B 'causes' A. When the latter chain takes place with long process delay, it is not customary for fast processing nervous reactive systems to filter 'cause' out of a very noisy process scale. Too many tempting signals arise to upset the planning.

This is no metaphor. Try the example of a moderately obese person who is dieting. It is the easiest thing in the world to slip up on a diet for a few days. It is the hardest thing in the world to provide the same amount of deficit signal. The system is simply not symmetric in its perceptions.

However there are some to whom the drive to save (e.g., in a Freudian sense, of all types), the drive for the deferred pleasure of acquisition, is as great a signal. It is rare, but it happens. Those who have that kind of drive, good fortune, and a few other ingredients, make up the elite.

> The senior author is aggressive. As a Federal employee, he was known to be aggressive in his Bureau. But that kind of aggressiviness does not necessarily lead to becoming an entrepreneur. It turns out that a colleague of his at NBS was also aggressive - J. Rabinow - and both individuals did become entrepreneurs. But the senior author was not an elite, nor parenthetically, is his colleague. The drive that is represented by acquisision is not really there. In both cases, there is a large drive to activity. This is no adverse judgment, simply a small note on different personalities.

That elite drive, when it succeeds in producing an income position, namely an integrated storage of value-in-trade,then is turned toward investment in both productive and nonproductive activities that involve the populace in the task of living.

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[1] Try on for size the study discussed in "One Half of Adults Lack Basic Knowledge", Phila.Inq.,p.1, Oct.30,1975.

Why can't the populace do that for themselves? They can, but only at a low level of productivity - even if technology were epigenetically available. It is only the drive of elites who raise the productivity level, using technology, to where the populace operates at a higher level of consumption than it would otherwise do.

We can now try to complete the thermodynamic balance by returning to the problem of estimating the balance for a city.

We can try to visualize cities like Philadelphia, or Boston, as we care to interchangeably. For model purposes we can imagine

Philadelphia - 1880
Philadelphia - now

Boston - past
Boston - now

Suppose we start from the premise:

1880 - Philadelphia - the minimum yearly standard of living for a family of 5 required $640.

(On one hand this could be considered a definition of the dollar; but it is also a measure of technology, for what went into the style of living - food, shelter, clothing, utensils, transportation, medical care - was a measure of technology. And the implicit assumption that an average family size was 5 is a complex coupling to how a style of living was achieved.)

We also will assume a population of 840,000, that skilled workers received $2 per day, unskilled $1.30 per day, and that they worked 10 hours per day, 6 days per week.

(a) We will compute the average family income as follows: We start with the existence of two classes. For the populace, we assume that the existence of a stable population over the generations time scale implies that society has not permitted too many people to die. Thus family income starts at the bare subsistence level of $640. We don't know how much above subsistence the 'middle class' tail can receive (or demand). As an a priori guess, from our previous data, we assume twice subsistence (e.g., the current median, income of $12,000 as compared to the subsistence level of $6,000). Thus the average populace (total median) income would be 1.5 x 640 = $960. However, as we have indicated, the elite likely claim half of the total income. Since they are assumed only to be 2% of the population, the population average is assumed to be 2 x 1.5 x 640 = $1920. Thus the total yearly income for Philadelphia is estimated to be

$$\frac{(2) \times (1.5) \times 640 \times 840{,}000}{5} = \$320{,}000{,}000$$

Note that we would regard three figure ($640, 840,000, 5) to be point-in-time variables, whereas the other two (2, 1.5) are slowly varying parameters that may have some modest pointwise fluctuations.

(b) As far as food is concerned, we have tentatively concluded that food

can be regarded as photosynthetic plant derived or animal derived (i.e., oxidative). Thus 'meat' and 'potatoes' might be used as the catchphrase summary. As far as we can see, there is a rough metric of annual meat consumption with affluence. But temperature effects (e.g., in very cold zones where the food chain is severely rate governed by plants, which supports a fragile animal chain that man has to adapt to, as compared to very hot zones in which plant food is abundant, and it behooves man to adapt to the differing food chain); ecological effects (again how the climate and weather influence the plant food chain, e.g., the difference in African grains as compared to those that were native to North America, Asia),[1] geographic effects (topography, and climate, e.g., mountains, oceans, river plains, and the choice of an adaptable food chain) all put some biases on the issue. Thus we are left with the simpler conclusion - people eat about 2000 Kcal/day.

Thus Philadelphia required a food input of

$$(365) \times 840{,}000 \times 2000 = 6.1 \times 10^{11} \text{ Kcal/yr.}$$

The average heat of combustion of gross food is about 300 Kcal/100 gm. (fats - 900, nuts - 700, grains - 350, cheeses - 300, meats - 250, milk - 200, poultry - 150, fish - 150, shell-fish - 50, fruits and vegetables - 50. Note, in current style of living, upper class food tends to the lower specific calorie foods. Thus currently there is definitely an association of body size with class. But, in other ages, upper class was marked by how well one ate, i.e., rotundity. Thus both extremely poor in one age and extremely rich in another could be quite obese, but from different causality. So as a first round, we wash out these 'culturally' biased results.)[2]

Thus Philadelphia required a food intake of about 4.5×10^8 lbs. food per year.

(c) The very division of requirements for a minimum subsistence level suggests that in the long run earnings to produce value-in-trade will be equally distributed among perhaps 4 compartments. We might call these

food
shelter
personal needs - We could identify this by the eupemism 'clothing' for both the body and the 'psyche'. It is a catch-phrase for all the needs of 'body' and 'spirit'.
'tools' - In a similar sense, tools are the running costs in a family by which it manages to support itself.

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[1] We are not prepared in a casual way, to quickly test the controversial issue in ecology as to the degree of evolutionary convergence of plants in similar climatic zones. Obviously much of the story of urban man is dominated by the temperate climate range in which he develops urban systems. Thus there is great significance to ecological convergence or nonconvergence.

[2] Our previous discussion showed a current association of life expectancy with income. We did not wish to imply that there was a single factor causal connection. Technology also influences life expectancy. In prior times without any scientific causal connection between public health and dietary measures and longetivity, eating well was a major luxury of elites, even if life were short. New life style optima are now possible.

The basic notion is that the elite 'entrepreneurs', those who control the technological means of production and the modes of production, insist upon a split of the value-in-trade that is developed among themselves. Thus 25-25-25-25. This is not Marxian, but Marxian derived. Namely it has nothing to do with capitalism. It has to do with how the elites perceive the budgeting of human effort. Namely, for operational purposes, the 20 modes of the human become so compartmentalized. It is not the case that other compartmentalizations aren't possible, but competing land uses and competing technological productivities is what forces the perceptions.

To cite some up-to-date example; take numbers for a retired couple, who do not deal with the fourth item and thus in principle have only 3 out of 4 compartments (1975 U.S. Labor Dept. Bureau of Labor Statistics - Philadelphia urban area).

	lower budget		intermediate		higher	
Food	$1440	(35%)	$1953	(31%)	$2418	(26%)
Housing	1477	(35%)	2222	(35%)	3500	(37%)
Personal	1262	(30%)	2171	(34%)	3499	(37%)
Medical		(12)		(8)		(5.5)
Other consumption		(5)		(5)		(7)
Clothing		(4.5)		(5)		(5)
Gifts, insurance,etc.		(4)		(6)		(7.5)
Personal care		(3)		(2.5)		(2.5)
Transportation		(1.5)		(7)		(9.5)
	$4179	(100%)	$6346	(100%)	$9417	(100%)

Clearly the nominal equal division among food, shelter, and all other personal requirements appears more evident, particularly as one moves toward the subsistence level. At the present time, one suspects that the increased longetivity (e.g., approaching 70 as compared to 30 in Neolithic times, with a large gain in the past 40-50 years with water sanitation), which has moved down to include attention to the poor, has begun to press the role of the medical shaman again toward elite status. Thus it is no surprise to find a high fraction of medical care within the lower income budget. In more ancient days, a detailed concern for the elderly poor was not a common mark of societies. Thus outside of that item, there are few novelties contained in the budget, except for a pertinent note on transportation. Note that transportation (presumably travel - presumably a large chunk devoted to automotive) rises very significantly as a social outlet for the not-so-poor. Namely social intercourse, an enrichment among the human modalities, is where a significant chunk of income goes.

It is from such numbers that current family income may be estimated, i.e., increase the lower margin by 1/3rd, raising it to $5600 per year for two, and increasing it by 1/3 to 1/2 as the cost for 2 children, raises the subsistence level to perhaps $7300-$8300. One can only surmise that the $5500-$7500 estimates we have made are in the correct ballpark.

One will see this gross lumping theme appearing in many formes. It is a valid means, in our opinion, to obtain an approximate estimate of the result of many conflicting dynamic microscopic forces that integrate up to the equation of state.

Thus we estimate that the minimum requirement, Philadelphia 1880, per family for food must have been of the order of

$$\frac{\$640}{4} = \$160 \text{ per family per year}$$

The average for the entire populace must have been double. (Namely one can pick and choose a market basket for an average penalty of a factor of two, over a minimum survival level). Thus the total family population average must have been about $320 per year.

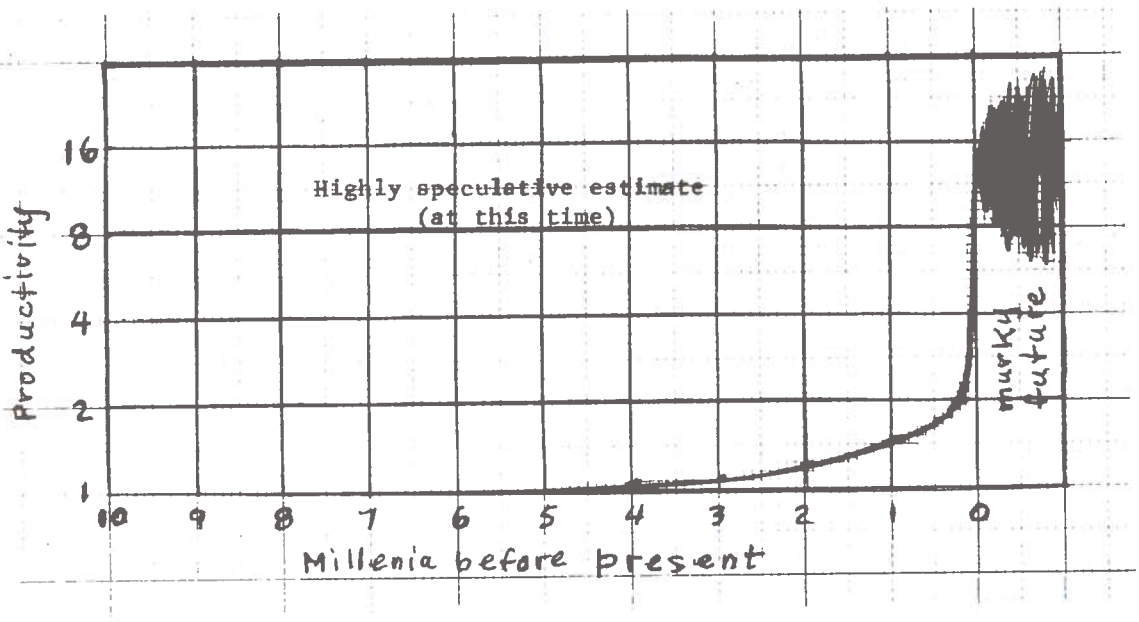
Thus the cost per pound of average food must have been about

$$\frac{(100) \times (365) \times 840{,}000 \times (2000) \times (4) \times 5}{(454) \times 300 \times \$640 \times (2) \times 840{,}000} = 8.5 \ \frac{\text{lbs.}}{\text{dollars}}$$

i.e., 12¢ per lb. Thus we now approach a very basic question

How does the populace support the elite who have invested the fruits of their labor in storage of goods, value-in-trade, and increased productive facility. We will attempt to show that the issue is one of the productivity of technology as used by man. We assume that the society shared a common social value function.

(d) In early agricultural days, the productivity of a man was unity (or very near unity). That is in a full work day a man (implying a family) could produce enough for subsistence. As technology changed, productivity rose - but slowly. We would take the rise to be somewhat as pictured below



Namely the exploitation of the onager, ox, horse, donkey, elephant, llama, etc., as beasts of burden gradually began to raise the productivity of the human, and then the exploitation of the machine - mechanisms haven't been developed with increasing efficiency and transforming competence[1] began to raise it even further. Thus, for example, we would consider that current productivities are of the order of a factor of 10, and that the productivity, as of 1880, in the U.S.A. was about a factor of 2. It is 'unfortunate', for modelling purposes, to be on the steep part of the curve, but this has resulted from the explosion due to a variety of cooperative factors. Predominately among them is the exploitation of natural resource, particularly high strength metals and long time oxidizable fossil fuels. But that dip into nonrenewable resources is beginning to approach its impulsive tail. The question whether a 'free' flux of solar, geophysicsl, or nuclear energy exists or can be found, can be answered as follows: Unlimited nuclear energy involves the same issue that limited combustion engines raise. It is materials limitations in combustion engines, and this relates to materials to confine oxidative explosions. The 1000°F limit of standard engineering design resulted. Nuclear energy is intrinsically hot high energy. The issue of the very immediate wall, e.g., even fusion by laser explosions, does not eliminate the problem. Thus the question of fuels and materials, the issue of proximity of living matter and hot nuclear matter, cannot be well resolved. Thus the issue must turn to the ultimate exploitation of solar and geophysical energy. They really are the only long term constants storage source that we have available. The issue is 'only' efficient converters and that we can answer with affirmativeness in an R and D sense. Efficient converters can be found. So the issue returns to the question - what solar conversion efficiencies will support what population? At 2 cal/min.cm^2 (1 for the half day) with, say, a potential matching that permits withdrawal up to 1/2 cal/min.cm^2, with say half of that put away for food, leaving 1/4 cal/min.cm^2, and for round numbers with half of the earth's surface available, leaving say 1/8 cal/min.cm^2, we might see what this means for the U.S.A. Its area is about 3.5×10^6 mi.^{2}. Thus we estimate it might support a possible population of 1.6×10^9 - at unit productivity, namely all a hard working population. With today's productivity, it would be a population of the order of 200 million. Thus here is our dilemma (or should we say our elite's dilemma)? If they insist on automating to produce high energy productivity per human, then the U.S.A. could only support its current population - drawing with high efficiency on renewable solar resources. But if population runs away, then either we must drop back - ultimately - to a more primitive technology, or elites must find excuses to get rid of excess populations, i.e., wars, and in which case nuclear wars will have arrived at a time of maximum convenience. (To kill for patriotic reasons is more acceptable than to kill for breeding reasons.)

By the way, that these numbers have some kind of reasonableness is born out by our crop experience in the past few years. We have reached productivity - admittedly with nonrenewable resources - that provides about twice as much food as we need. So one could take our estimates with a factor of two jaundice, a large apparent error, but the spirit of the calculation is right, and it likely

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[1] Namely, one transferred the burden to a larger beast then a still larger and 'hungrier' mechanical beast. The specific energetics remains comparable, but the overall energetics handled are larger. And only now do we note the cost in nonrenewable resources.

is more accurate than might seem.

Let us understand the implication in this kind of thermostatic calculation. We have quickly captured, within it, the theory of population regulation. We did not note, in our earlier Army reports, that population and productivity have gone together. And thus the same productivity explosion that we have shown for the past few hundred years has been paralleled by a population explosion.

Now the world wonders at its concern with population control. There is a lack of comprehension that it is not the intellectual that leads the thermodynamic thesis but the thermodynamic that leads the intellectual's thesis. It is part of biological self regulation that even the epigenetically formed intellect discovers the themes it has to discover. Thus it is the coming uncertain productivity regulation, which now dominates the uncertain population.

But actually, the productivity is not uncertain. It must go up in sophistication, but down in magnitude. Namely technology now is forced toward a new branch. The negentropy function is beginning to level, but it must broaden in its applicability.

Thus the human response in the world will be that population will broaden and flatten. This must happen. It is part of our social physics. The only problem is when. We cannot, at this primitive state of this science, guarantee time constants. Intuitively we sense a large amount of <u>now</u> and <u>ago</u> birth choice function (since what counts is when these are averaged over the past seventy years and compared to now) that has to relate to the averaging from the Great Depression - World War II period. Thus likely changes of perception of the population problem did not become meaningful until 1965. Thus likely, few major effects of policy will be clear before 2030, because certainly the fantastic depressed impulses of 1930 and the enhanced impulses of 1940's will rock the population boat at least out to 2000.

The fantastic backwash waves, as population brakes are applied so fast (e.g., family size of 6 at the turn of the century to now), obviously has to have fantastic impact on the family. The family unit, as we will see, is an economic unit for survivorship. With the productivity rising and now saturating, populace increase was needed but not large family units. People had to dry up their family size needs. Children are superfluous.[1] The average American home is not that kind of farm or factory family any more. Thus the completely confused picture of these backwater eddies rock back and forth. Our problem is to make a first order estimate when it will sttle down. We say perhaps 50 years. Namely our grandchildren's children. (Our grandchildren are already around.)

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[1]The senior author has four grown children emerging from his home. It was a personal choice function. The tumult of raising them in the 60's and 70's passed over him and all his friends, and the rest of the populace. Personal love is one thing, but a scientific recognition that their number was mismatched for the society is another.

If we turn say to China, we would characterize it by the notion that Mao has not sought so much a gain in technological productivity but more a rationalization of human productivity, whereby the same near unity productivity produces a much higher yield of food from the land. The crunch there could take place if population grows and technology grows. Namely there is no Utopia even in Communism. Namely, people, humans, have to work, they can't loaf.

On the other hand, the fallacy of Stalin's program of electrification for the USSR finally emerges. (We could never pin down our basic criticism,) Russia is electrified. It is not mechanized. It has spent all its strength to that end. Thereby, trying to climb by technological guts alone, it has not been able to rationalize its problems.

While we may have apparently gone far afield, we have managed to illuminate a little how population, and productivity, and technology, and wars are coupled. So back to our details.

We select a productivity of 2 for Philadelphia in 1880.

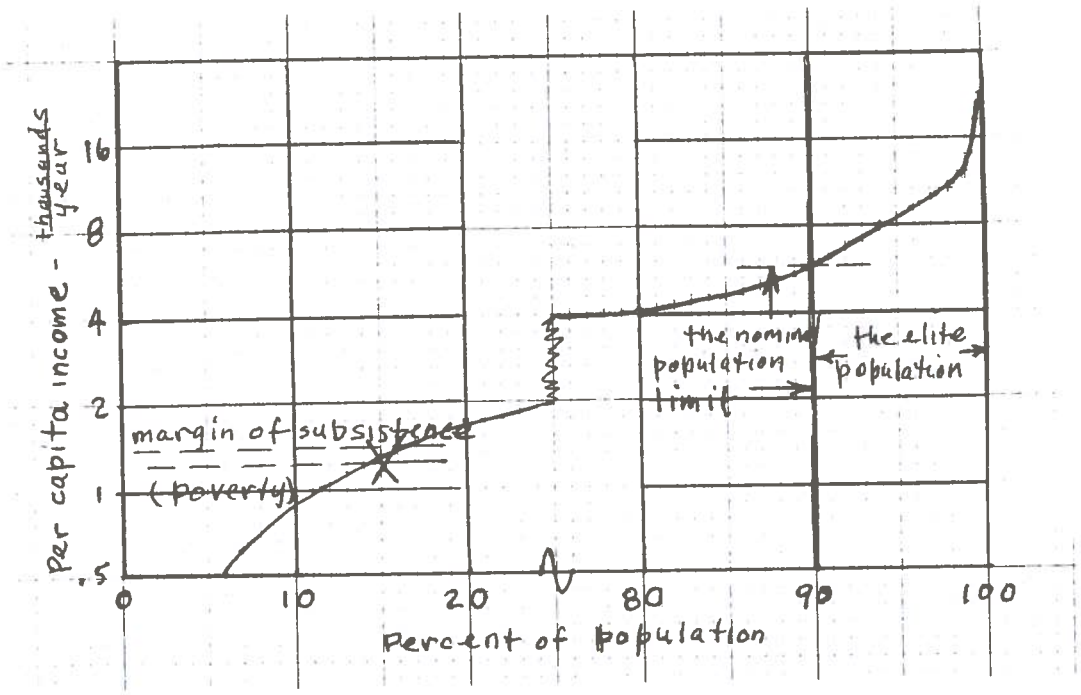
But regardless of the level of productivity, the elite require 1/4th the produce of a hundred in order to both maintain the productivity and live in an acceptable style. (As primates, they were accustomed to bossing 25-50. So that level of excess is imprinted in the selected human breed.) Thus 98% of the populace families support 2% of elite families by halving their produce.

(e) What is negotiable in this picture? It is the size of the family.

Note experimentally, we might say that with a productivity of 2, a family size of 5 was needed. With a productivity of 10, a family size close only to 2 is needed. This is what we must try to demonstrate. Note, whether in U.S.A. in 1880, or the USSR 1970, it is mother and father both who have to work certainly.

How do we encompass the family size design figure? The issue is tied to the cost of subsistence and technological productivity. We will indicate to the reader our modelling thus far.

Note in the following figure that the income curve is so flat that where it intersects the margin of subsistence is, in itself, not highly determinate. Both are close to the origin. But as we have seen in Philadelphia in 1880, the individual operating with a productivity of 2 - the unskilled worker - lacks a margin of 40% in order to live. That puts it improperly. He is a member of a family of 5 in which more than one works.



x marks the point of a free variable. Where this intersection takes place with the margin of subsistence is what determines the size of the family.

What we shall attempt now is a crude theory of family size. Namely we shall assume that a family (1880) was that size that at operating conditions of 1800 could support itself at the margin of subsistence. We aggregate living into four support categories - food, shelter, 'personal' needs for life support other than food and shelter, tools (namely the transformer support that the 'free' wage earner requires to assure a livelihood). Thus the family balance, 1880, is represented crudely by

$$\frac{\$640}{364} = \$1.76 = 44¢ \text{ (food)} + 44¢ \text{ (shelter)} + 44¢ \text{ (services)} + 44¢ \text{ (tools)}$$

Our problem is to estimate how many people are in the family.

We shall take the following model: <u>For remuneration</u>

	cost in energy Kcal/day	production in energy-Kcal/day	pay per day
heavy labor (father)	3000	6000[2]	$1.30[3]
normal adult (mother)	2000	4000	.87 (.58)
children	1750	3500	.75 (.50)
machine	0[1]	-	

For food: Our previous numbers indicate an average food cost of 9¢/1000 Kcal; but a cost half of that for the poor.

	food cost/day
father	27¢/2
mother	18¢/2
child	16¢/2

We can estimate the family size from this balance. Suppose n children. Then

$$\frac{27}{2} + \frac{18}{2} + \frac{16}{2} n = 44$$

$$n \approx 3$$

Thus the family size is about 5.

We can estimate the family income now. It is approximately $1.30 + .58 + 3 x .50 = $2.38. If the whole family is working, but

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[1] There is a capital cost, but we will start with a primitive zeroth order industrial assumption that a machine does not have to be fed. Even prior, when the machine was in whole or part an animal, it was largely expected to feed itself (from the food chain). Obviously, one quickly finds out that machines cost, i.e., that they have the equivalent of internal friction, so that in large scale operations, matching impedance concerns are major, but at our beginning primitive level, we will omit all such model refinements.

[2] We have assumed that the elite provide the productive equipment which in 1880 was represented by a factor of 2.

[3] We have assumed pay is proportional to production. But obviously there are cultural factors, whereby the pay is discounted for women and children. We simply have not provided that discount. (Alternatively, one might discount them by say a nominal factor of 1/3 on the basis that they are not an indefinitely certain source of labor, i.e., whether primate machismo, their lesser stamina, or therefore their greater proclivity to suffer damage. Note, we are not arguing our morality.)

closer to $1.30 + .58 as a reliable estimate.[1] Thus the average of respectable and dire poverty puts families at the survival margin of about $1.80 per day.

For shelter: We will assume that there is a very slowly varying schedule on how much space is required for a family to live in. Namely 1 or 2 people can live in one room. As the family size grows, this may become asymptotic toward 2 rooms.

Thus we can surmive that while 2 people can live in one room, city construction since the middle ages has encouraged multiple story building at little cost greater than one story. Thus one can regard that as family size grows, it begins to be more common to find two related families in three rooms. Thus as an approximation, we find it difficult to put down anything but a uniform charge by landlords for two families per three rooms, independent of the size of the family. Thus the charge will tend to be uniform, independent of family size, about 44¢ per day per family.[2]

On the other hand 'personal services' (all of the individual needs of the members of the family) have some sort of schedule. If the total family 'take' is $160 for a family of five this would represent an 'average' of 9¢ per day per person. We can imagine the schedule to be based on relative weights of

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[1] Among the urban poor, there has always been two states - those families which were respectable poor, namely the family was working and no outstanding crises were on the horizon; and those who had gotten dragged down. Namely one child too many, a mother who had gotten sick (or a father) and the family structure then basically disappears. That survival margin is so slim that the system most often acts unstably at that border.

While the conclusion on family size seems weakly drawn, it is only the limited study time available on this present phase that prevents a more complete breakdown and documentation of the thermostatic state. A recent issue of the New Yorker, "Profiles: A Welfare Mother", Sept. 29, 1975, provides an anecdotical representation of what it is like to live at the margin of survival. We hold no brief for the obscene character of life so conducted, but clearly the primitives of food are a dominating aspect of such life. It is not that the threat of no food dominates the family size. It is that the family size becomes dominated by the margin by which it can supply food. A parallel picture can be derived from H. Mayhew's, London Labour and the London Poor.

[2] We will cite two illustrations of living state. One, an inquiry to the Phila. Inquirer (July 28, 1975, p.19c) about Holy Ghost houses in Philadelphia, elicited the reply that they were compact 3-story houses erected in Philadelphia as early as the 1700's. Without public transportation, these tiny houses - single rooms above each other - were within walking distances of employment. They were also called high hat, Faith, Hope, and Charity; and bandbox houses They existed for the poor up through the 1940's (now they are being converted to town houses). They were found in center city Philadelphia from the Delaware to the Schuylkill Rivers, north and south of Market Street of the order of a mile, wherever and whenever 'high' quality building wasn't involved. They are also described in Boston, and can be found for a more extended period of history in London.

1, 2/3, 1/3, and thus

	relative weight	money cost 1 day
father	1	16.5¢
mother	2/3	11¢
child	1/3	5.5¢

Thus again, the personal service budget is 16.5 + 11 + 3 x 5.5 = 44¢ per day.

And for 'tools' (that from which a living is wrested) we will select the same schedule as for 'personal services'.

This description seems to be a peculiar way to fill the thermostatic equation of state, particularly since it did not seem to relate very much to the materials compartment and the economics compartment. We must explain the process.

The main notion is that of a thermodynamic equilibrium state. Let us first imagine that state with a very low technological productivity. Basically most activity goes toward cultivating the food chain. The species - here man - has to find an ecological niche he can fit into and exploit the food chain. We promise that he is doing this on the basis of agriculture rather than hunting-gathering.

A very fundamental point has dawned on us in discussing the operating balance of the human system. We have been discussing a thermodynamic equilibrium state or near thermodynamic equilibrium state. However we have not properly explained how and why that state can exist with a population growth rate. We have correctly, but incompletely related the growth to the technologal growth rate - an extensive value system (a negentropy) related to the human mind. That has left us with an unexplained dilemma. Why did population rate explode so 200 years ago with the industrial revolution, at the same time that technology exploded? In our view, the rate of production of new scientific-technical or 'abstract' ideas did not necessarily change, only the realization in engineering. We believe we finally have the basic 'coupling' process.

We suggest that what leads to support of these nonequilibrium growth rates is the use of nonrenewable resources. The higher than unity productivity gain and population gain of hominids we see emerging first throughout the Paleolithic period. And then the relative growth of homos (at the expense of other hominid lines) and then of homo sapiens sapiens (at the expense of Neanderthal), we propose is due to that small margin of use of tool materials. Then with agriculture, the increased use of nonrenewable resources let to the Neolithic growth of man. And finally, the real gobbling of natural nonrenewable resources offered support for a fantastic (though still near equilibrium) explosion of population.

We suggest that man has had his playday for 200 years. Now the sustained growth has to be paid for. The levels that can be maintained

depend solely on renewable resources. So the problem returns to high technology utilization of nonrenewable resources.

We suggest that a species can grow in population by one of three ways; one, it can grow by rearranging the food chain in its favor so that it can support a greater fragment of its own species[1], two, it can be supported from nonrenewable resources in its ecological milieu[2], or three, a physiological defense is developed against debilitating mortality effects.[3]

During the hunting-gathering phase man kept changing his position, relative to the food chain, by drawing upon a very thin amount of nonrenewable resource - tool material. Being a highly dilute species in the ecology, this did not represent much of a change in the ecological balance.[4] Thus in the main, it was a new abstract technology which man brought to the world of life competition. But basically, it was a slow process change with rates to be noted over many millenia.

With agriculture, man began to draw much more heavily on nonrenewable resources and the urban ingathering became latently possible.

The serial nature of exploiting technology, rate-governed its growth. The rate of development of ideas in the mind was not affected, but the reduction to practise - the character of having the idea, the practise, the problem, the time, the materials, the necessary technological precursor - all governed the rate at which productivity and the exploitation of resources upon which physical productivity was based. It was the possible exploitation of coal and mineral products, and the metals, following in the order of: post-Roman empire agriculture, growth of trade and the commerce in medieval cities, the expansion via the sea, the further growth of cities, and an increased productive agriculture, that encouraged the population explosion of 200 years ago.

The effect of that materials exploitation, like all high reaction rate processes, explored the total potential of the available field. <u>It did not change the basic potentials of the field</u>. Thus a major human process that benefited was the life expectancy, and the diminution of hunger. Life expectancy jumped from 30 years to 70 years. The 70 years was always a latent potential. 'Now' a larger proportion of the population could achieve it.

Hunger was always a prospect facing a large segment of the populace. 'Now' by the large gain in productivity, the margin would not catastrophically engulf so many of the populace.

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[1] Obviously, or there would be no way for a new species to find an ecological niche.

[2] This is the common means, as a deus ex machina, that humans domesticate and raise other species - both plants and animals.

[3] Such immunity may be acquired naturally or - in the case of man - developed by an intellectually guided technology.

[4] If we adopt the Paul Martin thesis, <u>that</u> 'small' interaction was sufficient to wipe out all of the large predators in the Americas in a period of about 1000 years.

Note, on national scales, the fluctuations in food productivity are still quite large. No nation, even the super giants, are immune. And 'now', with material resources being limited, the prospect of famine for many regions of the earth are not only certain, but have moved up on the time scale of estimation.

Thus at any time and place, to a large extent, it is not relevant scientifically to ask what the people do. If they have achieved a population growth and a productivity, one can surmise and fill out a schedule of engineering activities, of industrial-agricultural activities, that will fill the bill.

But it is the opposite problem which concerns and misleads the engineer. Given an ongoing industrial-agricultural level of activity, or given a proposed change of that level, how will population and productivity change?

Here, it is very difficult for either scientist, engineer, or even political administrator to understand the fundamental issue. That issue is whether the elite are satisfied with the existing status of the system they are immersed in. (The elite refer not only to those who are elite but those who potentially will become elite. The problem, is their perception of whether the opportunity they wish to capture is open to them.)

If the elite are satisfied, there is not going to be any significant change of the status quo. They will invest and reap rewards at the rate they are doing. They will encourage the introduction of new technology at a rate that they have already become comfortable with. The rate of depletion of nonrenewable resource will continue as is.

Thus within that background, we saw large scale social change as the elite became the commercial and industrial producers of 200 years ago. It was their thrust which has governed the level of existing industrial-agricultural expansion. It was those rates which they called for which governed the changing size of the family and the growing population. It was their perception that selected power machinery and automation and more automation which has dropped the need for a family size down to near reproduction while still encouraging a growth of population.

The extrapolated solution toward greater automation with even smaller family size was beginning to show the need for a population levelling off - even if the nonrenewable resources were available. Now that we simultaneously find that the materials are no longer to be available soon, the need for levelling, perhaps even decreasing,becomes quite necessary.

Thus the elite must also seek a change in direction. The basic question that we face is how to exhibit the entire flow and potential structure by which all - elite, populace, politician, scientist, engineer, administrator - can see his future options. And in our particular case, in this study contract, how national and urban transportation system needs can be seen. One does not have to stress that our transportation systems are nonrenewable resource profligate. The issue is not going to be resolved in the dollar domain - although dollars may serve as a measure of what is involved - but in the nonrenewable resource domain.

As a suitable climax to this project, we were asked to provide a summary of longe range R and D transportation requirements for a Mitre Conference on

on Transportation issues (September 17-19, 1975). We prepared a position paper (see forthcoming proceedings), a summary(which is here included), and we began to interact with DOT systems personnel sufficient to begin an early format for systems' modelling that will be able to answer the question of the form of a national and urban transportation data base, and how it may be used to determine transportation planning.

But first our Mitre summary:

Social Physics

This note is a brief introduction to a new interdisciplinary branch of physics. It is intended to put that extension of physics and its possible applications into perspective.

Social physics is a science. Practising that science is an art. Let me try to make that clear.

The physics of fluids (hydrodynamics) is a science. Practising that science is an art. Every engineer and scientist who has worked with this field knows it. So I'll 'explain' flow physics, to provide both analogue and necessary ingredient to explain social physics.

In flow physics, I need balances in three compartments:

energy balance

mass balance

action balance

Two notes:

While physicists are commonly trained to do the action balance as a momentum balance, it is just as proper, and essentially equivalent to do this balance from action[1] - the summed product of energy and time.

For many problems, the physicist will say the fluid is "incompressible" and so drop any other consideration of the mass balance (Mass, he will say, simply doesn't change). He will then only do a one compartment balance (the action, or momentum balance).

Now, upgrade the problem of complexity to the physics of a society of living things (bacteria; live flies - the allusion being to the notion that physics need not only deal with the motion of dead flies; cows; wheat). Then, one needs to

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[1] E.g., as a principle of least action for nonconservative systems. It is more convenient, for systems with long time delayed internal degrees-of-freedom, to formulate by action rather than momentum.

deal with balances in four compartments.

energy balance	action balance
mass balance	population balance

If you conduct such a system, namely if you are a farmer, cattleman, or drug company, you must learn how to deal with these compartments.

I have neglected, thus far, to add an additional idea of the governing potentials which dominate the fields and thereby provide operational boundary conditions.

For the flow field, mimimally, I have a shared potential of physical temperature.

In addition to temperature, for the living field, I have the potential of a shared "value" system produced by the common genetic heritage of the living system, whereby ensemble members were, in fact, able to reproduce and maintain population - not only as number but as kind.

Now we can introduce the social physics of man. It deals with a five-compartment balance.

energy balance	action balance	
		economic balance
mass balance	population balance	

The economic balance is commonly viewed as the "account balances" of pure economics, and unfortunately, economists have felt they can do their versions of "social physics" by this one compartment balance. I suggest not. The autonomous characteristics of social dynamics is not economically determinate. Five compartments are needed.

And in addition, we now need five potentials[1] minimally -

physical temperature
an available store of chemically bound free energy
a genetic value system
a shared epigenetic (learned) value system
the rate at which technological innovation, as a productivity gain, changes and is accepted into society.

It must be specifically noted that you cannot have an operative society without a shared value system.

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[1]The proliferation of potentials is not solely characteristic of a social physics. One already begins to find such proliferation in chemical thermodynamics.

So - these five balances and five potentials are minimally sufficient to do all sorts of social physics boundary value problems. Good hunting!

And what can you do with the construct? You can make scientific calculations out for three generations in time. What do you need for boundary conditions for such predictions? Knowledge of the past state of the social system for the past 50 generations. Fifty generations will give you three more.

Why is so much detail required? Because human society is not a melting pot, but a mixing pot.[1] Fifty generations worth give you a well stirred picture of the society - the earlier 25 generations are the archaic view of itself that the society holds; the latter (immediately prior) 25 generations are the enculturating process.

There is also the possibility of doing one generation (20 years) calculations. These are not-quite-equilibrium calculations. They are really war-to-war calculations. For that one must add one more "latent" potential - the potential of a "perceived threat".

More detailed exposition and study is described elsewhere.

> This summary was sharp enough, that it finally conveyed the notion that a social system's data base for all major policy decisions including transportation planning had to be constructed around these 5 compartments, and the 5 potentials, and that the thermostatic equation of state was then a dynamic restraint tie among the mean state of all five of these compartments.

The data base for national and urban social planning consists of:

1. Population potentials. As the human populace, ergodically, tramples a physical region, they gradually sample all of its potentiality and thus determine the supportable densities of the region. If this is represented as potentials by fraction of total population data, rather than on a per capita density basis, one will find potential curves that are remarkably slowly varying in historical eras. Conversely, the history of development of the potential picture will clearly show the start up flows into the region (e.g., the U.S.A. for the past 300 years). A model of the inhomogeneous diffusion patterns that the geographic land mass permits will be gotten.

That picture will be a diffusion model. It will suggest its own internal reasons why, in trying to satisfy a five compartment balance, population is distributed the way it is, and has to be. It will tell you what you can and cannot diversify and why. It will be controlled by resources, topography, availability of land for particular uses, natural transport paths.

The best test of the validity of the model, is after developing it by a

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[1] It is not usual, in fluid dynamic problems, to characterize the present state in terms of its past history - unless one is dealing with thixotropic fields. Remembrance of things past is the case in social fields.

hard set of data collection, the problem can be given to other technical persons without the detailed background (e.g., a foreign expert) to see how well he can produce the potential curves from a minimal physical description of the territory. That test - if it involves the 5 compartments and potentials - will be a measure of the extent to which we have developed a hard social physics.

2. Materials resource potential Living systems prior to modern man were simply concerned with foodstuffs. Modern man has added the use of materials in a technological sense. Thus we have to preserve a difference between these two potentials.

(a) Food stocks (i.e., biomass utilization, independent of kind. This should present the utilization of the biomass, normalized to the total national utilization. It is our premise that the potential curves will be slowly changing historically, and they will show both the expansion across the continent, the feeling out of the regions of major productivity, and the effect of more modern technology such as fertilizer in influencing more ancient patterns of land exploitation).

(b) Mineral utilization (This too should be normalized to total usage. It should show the effects of the opening of new technologies, as well as the available land potential.)

3. Energy resource utilization potential (This should be normalized to total consumption. The production of materials for energy is already counted within minerals utilization. How man gets a multiplier effect from technology - whether from the use of a material, or from its energy value - can differ from case to case. These two compartments indicate something of the nature of the allocation problem.)

4. Productivity activity potential (This is to be presented as consumptive action, namely the product of energy-time per year, normalized to the total action expended. However, it divides into two categories - that which is spent by men and that which is spent by machines.)

(a) People action (This relates to their total action expended in producing balances in the 5 compartments. It does not relate to their nonproductive activities. We recall that the life cycle is conducted so as to produce 'leisure time' and time for other activities. For example, the Hebrews assigned one day in seven for activities devoted solely to discourse with one's Maker.)

(b) Machinery action. (This relates to how the duty cycle of other energy consuming systems, largely making use of nonrenewable materials resources, are scheduled. It should show the changing role of technology in the production process).

5. Value-in-trade potentials (While clearly all of these processes could have been conducted with no other potential markers - other than population number, material mass, energy, and kind of activity - man will not conduct these transfers from region to region without the counter of value-in-trade. Namely there must exist a pricing and value system. This is independent of the economic or political system. At the present we will not

attempt any technical distinctions between private ownership systems and public ownership. In both cases, control of stored wealth lies in the hands of elites. The difference between the two systems is how legal title and physical storage in achieved. This will, in more detailed descriptions, cause technical details of presentation to be altered. However the recent award of the Nobel Prize in economics to Kantorivich is for his convergent work in which he has succeeded in bringing the Soviet pricing-allocation system essentially within the Western tradition of pure economics.)

(a) Value-in-trade potentials for people (Likely, as before this should relate to family income earned in productive activity, and be normalized by total family income.)

(b) Value-in-trade potentials for machinery (This should relate to the monetary value produced by machinery, normalized to the total monetary value. One note: With regard to absolute metrics among inflated or constant value dollars or other possible choices, it is likely that the appropriate metrics should reflect any one of three normalizing parameters - total population, the median family income, or the total value of the industrial-agricultural system, i.e., its 'wealth'.)

(c) The annual savings potential (Normalized to population, these potentials should reflect on how much savings per year people can accumulate to add to 'wealth'. It is likely that this potential should be measured not as savings but as physically realized investment into productive industrial-agricultural moieties.)

(d) The total net cumulation of wealth (normalized to population, these potentials should reflect on the total wealth stored as productive industrial-agricultural moieties.)

Besides these 'nodal' potentials which represent the abilities of these potentials to create fluxes in each compartment, there are the overall potentials within which the network system is immersed.

These are represented as over-potentials which also have some geographic division.

6. Average temperature potentials (Actually, they include, in greater planning detail, minimum and maximum temperature, rainfall and solar distribution, certain correlated products of these variables because photosynthetic growth depends on these correlated variables, and a number of other ecological variables that relate to the productivity of the land for permitting biomass growth. It is outside of our current scope to specify these with any detail.)

7. The technological multiplier (What the relation is between power use in machinery as a whole to produce both the yearly energy consumption of the population, e.g., its near 2000 Kcal/day per person, as well as the gain in wealth - which can also produce the future technological multiplier.)

8. Total nonrenewable materials stores (Normalized to the population. We know what the solar constant can produce as a fixed potential store for biomass. On the other hand, the nonrenewable store is a large reservoir which

has shrunk in the past 200 years. We are suggesting that this potential is the basic potential that must be watched for future growth. If we could stabilize this potential, or make it very slowly varying, we will have increased our national time horizon.)

9. The genetic value system (Our 1967 paper, Iberall and McCulloch, has characterized the nature of the human action modes. It is quite useful, but not absolutely necessary, that operators have some notion of these modes. The effect of introducing a national television system may not change the specific human action modalities, but it really changes the characteristic form which say the sensory attention modality takes. Time scales approaching 8 TV hours of family use per day represents a serious rescaling of human action. It is premature to make out a case, but knowledge of this potential system is of considerable significance.)

10. The epigenetic or learned value system. (This is the most difficult of all to qualify, let alone quantify. It is related to what Toynbee and Spengler have identified as outlook. It is far too premature to attempt to identify this value system and its changing locally. However we can suggest some notions that may permit it to be characterized nationally, say per each 3 generations. e.g., 1700, 1770, 1840, 1910, 1980. We have tentatively decided that the value system has to be identified topologically - in a field of highly diverse notions to be found in the mind space - with those cues to action that get very strong affirmation both in words and deeds.

Tentatively, we believe the following list indicates the salient categories. They are posed as questions to be answered by a catch phrase. (An illustrative catch phrase is indicated in parentheses.)

How does the populace make a living? (By hard work.)

How does it conduct family life? (Strong control by dominant father, 2nd in dominance mother, and children to late adolescence).

How does the society procreate? (By one family structure with about 2 children.)

What is the dominance ordering of productive activities? (Judging, doctoring, governing, trading, abstract designing, manufacturing, farming, making, religioning, servicing, abstract thinking, teaching).

What is the ordering of nonproductive activities? (sleep, sensory attention, physical play, escape, sex).

How does it run the local community? (Family associations organized legally into urban settlements with a dominant leader).

How does it run the central government?

Who are the authority figures? (Fathers, mothers, peers; appointed or elected officers; intellectual figures; elites, e.g., whoever is accepted as having people-power).

What will the populace die for? (Duty, country, ethnic identity).

What view is held of the outside world? ('Our' nation, e.g., Rome is the center. The world is organized under a Roman hegemony. There are competing international leaders. A varying system of trade and war coalitions exists.

What view is held of nature? (Nature is describable by physical laws, including the consistent descriptions of other disciplines - e.g., chemistry, geology, biology, anthropology, sociology, psychology.)

How does the populace react to: neighbors; strangers; enemies; authorities. (Neighbors - social interactions with neighbors in farms, cities, lesser in suburbia; strangers are tolerated with suspicion, admitted to social intercourse slowly; enemies are tolerated with a passive uneasiness; view of authorities is loosing its strength.)

Given a set of potential curves over a country's historical times (e.g., the past 500 years, by 70 year intervals, or because of the U.S.A.'s limited history, its more detailed picture for the past 300 years, such as 1675, 1725, 1775, 1825, 1900, 1975), what can one do with these? First the mean value for each compartment, e.g., population, materials and energy utilization, food production, annual and total wealth, represents the cumulative operating point of the thermostatic equation of state. We propose that we have suggested ideas by which these variables are connected. Thus the specific piece of science to be tested is what autonomous factor determines the growth level, e.g., of population. We have suggested a tight correlation with the utilization of nonrenewable resources, and we have suggested that by the time the velocity of money has settled down, the start up period for the nation was past. (Namely, nearly so for the past 150 years.)

We suggest that the overall balance for the next three generations can thus be estimated by careful study of the availability of nonrenewable resources.

But now turning to internal fluxes, we suggest that the past, present and future character of the transport system can be estimated by examining these potential diagrams. Thus this grossly lumped system can model the large scale national processes.

Assuming that these large scale long term figures are held in mind, one must sense the dynamic perturbations that fall on this scheme as one replaces some more temporally located fluctuations. Namely the 3 generation averaged equilibrium data each have to be decomposed into fluctuations caused by major wars. We do not propose that this is done in great detail, only that a few major wars be studied, e.g., at most the Revolutionary War, Civil War, World War I, and World War II. The causal impulses that these give rise to, in materials use, in commercial expansions, in new technology represent the dynamic ferment of the society. As we have implied, we do not know the detailed dynamic form that the fluctuations take, only their time scales. They depend on the time localized potentials of 'perceived threat' that lies in the minds of particular elites. Thus this mid range frequency phenomena is

indeterminate, even if the process looks more determinate in 3 generations. Namely the longer term national capabilities govern in the end.

Assuming now that we have both some sense of the long term national character (in its potential figures) and its generational fluctuations, namely what has become its style of international response, we can now approach the detail of modelling any urban area.

The gross boundary conditions for the urban area have been set within the larger and longer national construct. A city does not rule itself and determine its own destiny.

Now the same compartment details have to be put upon the city. Mathematically speaking, the city is a singularity - loosely speaking a population pole. The study of the same potential growths in historical time, will indicate a change from when the city held its own agriculture support area within its operating confines, and when it broke loose and became a storage depot, crossroads, A.C. flux source. Namely manufacture and commerce rather than the production of its own food biomass took over. Thus the balances in an urban area relate to a much closer regulation of inputs and outputs.

The higher frequency time scale response of the urban area thus results in the average potentials and fluxes over the day - these result from the driven daily fluctuations, the basic 'life' process of the city; its 3-4 day limit cycle reactivity (which can be lumped into a weekly subharmonic); its seasonal character over the year; its 3-4 year limit cycle reactivity; and finally how it blends into the national generation scale of war, and the 3 generation equilibrium.

The 3 generation equilibrium scale puts its inexhorable pressure on the city, which at most the city can distort. The city must be prepared to deal with the fluctuating exigencies of each war period. Given the former and some estimate of the latter, then one is in a position to examine the modelling consequences of urban transports.

Responding to the generation changes, the city must design its transportation system to fit the fluxes required to maintain the compartment balances. In particular, the dynamic range has to fit the daily and weekly process, and the seasonal process. It has to withstand purely 'political' process changes at the 3-4 year level that are not tied to real compartment needs.

Since much of the city's function is commerce and production, the large scale problem it has, at urban scale, is the design of storages and flows from storage of all the compartments. It is unfortunate that the modern automobile destabilized the urban area (creating the urban-suburban resonance), so that multiple function with some modest distributed field characteristic wasn't achieved. The current (past 2 generations) city is unstable at large size, with its urban-suburban resonance.

Simply put, the large city is not dead, but it has to be supplied with an adequate productivity base within it. Since daily transport has become rate governing, and there is no local technological way to solve that, except to scale cities down to operable size, the only solution is to create a more

uniform more homogeneous domain. All parts of the urban-suburban domain have to become more nearly equally productive. Then a more rational balance among all compartments can take place. The limiting size will then be rate governed by other fluxes, e.g., water supply for the domain, removal of wastes, the availability of commercial and industrial fluxes to the region. Thus, this is a first round modelling for urban areas.

Summary

This study contract called for us to provide a systems model for transportation planning. It required that we develop computable models, and indicate the required data base by which in fact urban transportation systems could be studied in accordance with our proposed statistical mechanical and thermodynamic scientific model.

It required that we relate urban transportation problems and the socio-economic framework of the urban area. And finally, it required that if we succeed in our initial objectives, we should indicate how this physical scientific based model can be further developed and its applicability tested.

In short, to capture the essence of the requirement, we were asked - in accordance with our original unsolicited proposal - to develop the form of a complete reductionist scientific theory for social organisms and how it may be applied to the institutional forms that the particular social organism, modern man, develops, and more particularly to the institutional form of concern to our sponsor - the transportation system of an urban settlement.

Since our approach (a social physics) has been on the historical agenda since the Enlightenment, but never developed,[1] and the potential technical reader can be easily confused by the plethora of different kinds of modelling, it is essential that the fundamental nature of this systems' construct be understood.

On the Kinds of Modelling

The following are the levels at which modelling discussions are held:

1. "Bar talk". Presumably developed by man, as soon as he learned to speak, e.g., 40,000 years ago, and could begin to communicate his speculations and fears about the world of phenomena around him.

2. Philosophy, loosely. It is quite possible, by the beginnings of urban organization, e.g., 6000-8000 B.C., more certainly 4500 B.C., or with great certainty about 2000 B.C., as illustrated in the known urban-oriented codes, that classification and codification about nature, man, and society had begun to take place.

3. Metaphysics. Clearly, by the works of Aristotle (350 B.C.), a theory of prior knowledge, namely the character of the first or primitive assumptions one has to make in order to deal with the character of nature, man, and society, was developed. A path toward scientific description was begun.

4. Philosophy, more restrictedly. From Aristotle onward, the possibility of a systematic 'scientific' (parsimonious description, standing in one-to-one

[1] It is interesting to note, at the time of writing this summary, that a first biological attempt, Wilson's Sociobiology, at a social systems' reductionism has come out from Harvard.

correlation with observed phenomena) description existed. The task was first taken on as a purely intellectual exercise by philosophers.

5. Physics-first round. By the 16th and 17th Century, a need for the directed observation known as experimental as well as purely intellectual observational science had become clear, and the challenge that Aristotle had laid down - laws of motion and change in nature - had been accepted in physics.

Its apotheosis was the development of a Newtonian physics. Its successes, in both the practical problems it undertook - the keeping of time, the motion of projectiles, the strengths of building materials - as well as the more philosophic - e.g., the motion of the planets - quickly established it as the prime construct for scientific description. It became the cornerstone of the Enlightenment, an effort to extend its application to all of the problems of concern to man.

But 18th Century physics was not up to the intractible problems of nature, man, and society. Thus that first burst of rational enthusiasm fell to the wayside. The problems that destroyed the effort were those that seemed to possess 'historicity' and 'evolution'.

6. Eclecticism and confusion. The result of the 18th Century and then the 19th Century studies led to a quick diversification into many disciplinary paths. Empiricism, engineering study, experimental study, narrowing of the descriptive horizon, stratification of study, deepening of study were the paths selected. Although search for a general unitary theory of phenomena was given up, phenomenal progress was made in a variety of specialized fields and by specialized methodologies. A few relevant ones will be mentioned.

a. Dialectic materialism. In the 19th Century Marx and Engels blew the whistle on the inability of a Newtonian physics to deal with the laws of motion and change in nature, mind, and society. Instead they proposed a new science, dialectic materialism, that could deal with these phenomena. Their endeavors, validly opened the door to social evolution. This was then followed by a geological evolution (Lyell), biological evolution (Darwin), and then again by a social evolution (Spencer). Unfortunately, their dialectic materialism still remained an exercise of a metaphysical nature, and thus it has not really provided any scientific (parsimonious) descriptions.

b. Engineering. By the efforts of the philosophers and scientists of the 16-18th Centuries, it became possible for engineers to train loosely in those disciplines and apply a restricted scientific view of natural phenomena to the material tasks that have become identified as engineering - structures, machinery, materials.

c. Physics and thermodynamics. Physics, meanwhile, did not sleep. It simply restricted its attention, and by doing so, revealed the whole activity structure of the atomisms of nature during the 19th and 20th Centuries. It also developed a metascience - in thermodynamics - but did not fully exploit that field.

By sticking close to detailed process, and leaving the intermediate range of sizes - the matter of everyday affairs - to engineers as "applied

science", it took off toward the small and the large, and in fact, in the 20th Century, stemming from the giant work of Einstein, discovered historicity and evolution in the large, and through quantum mechanics and nucleosynthesis, the correlated processes in the small.

Now, as applied physicsl scientists, via thermodynamics, we are prepared to return to the unfinished business of the 18th Century, and attack the problems of intermediate range - of nature more proximal to man, mind, and society - by application of 17th-20th Century physics.

So what do we have to compete with?

7. Logical systematics. Post Aristotle, we may jump to B. Russell. By the development of modern logic (logic includes mathematics), new modes of logical analyses of systems of phenomena were opened. These may, perhaps most generally, be referred to as logical 'network' problems. We would classify the issues in McCulloch-Pitts neural network models, von Neumann, et al. on the problem of computability, the logical theories of the Turing machine and Post, the theory of games, operational research strategies, pattern recognition and artificial intelligence studies, all in this class of logical modelling. Its basic foundation really remains philosophic.

8. Tautological accounting. This method really deals basically with flux balances. Its inspiration, intrinsically, is whatever led to D.C. network theory, e.g., current balances at nodes. Thus D.C. network theory, accounting balances, 'pure' economics, or H. Kahn's extension of operation's research to national defense balances are examples of such modelling.

9. Generalized network modelling. In mechanics, the theory of small vibrations became highly stylized, particularly via the Lagrangian and Hamiltonian descriptions. It helped the field of acoustic phenomena, and electrical phenomena to develop into a very standardized form. Particularly post Steinmetz's teaching, the engineer was prepared to use his methods for very generalized networks. The rather precise justification and limitations that Nyquist laid down (in Nyquist-Johnson noise) using Einstein's Brownian motion theory were quickly absorbed and forgotten. The ability to attempt any kind of connected chain of phenomena began to be claimed by the engineer after World War II. Actually all he had available was a notion of the fluxes and storages, and so could rationally 'imagine' resistive and capacitative type modellings, but with a vague notion of 'feedback',[1] some sort of black box representation of resonance phenomena could be achieved. Current examples of such modellings are the Forrester-Meadows social modellings, or the Guyton cardiovascular system modelling.

Their defect, as autonomous systems' models, is that they have no parsimonious basis for dealing with causality, they cannot eliminate redundancy or

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[1] There are very precise notions of feedback in electronic circuits and electromechanical circuits, but that does not mean that the notion is immediately applicable to all of the other nets to which it is casually employed. The character of the confusions is clear in such an article as P. Henshaw, "Developments in Cybernetics - ASC Origin and Future" ASC Cybern. Forum 8, 15, Fall, 1975.

contradiction, their descriptions are not necessarily isomorphic with the morphology of the system as they decompose it, they have no way to guarantee large domain coverage at all of the singular states of motion and thus how the system determines its stable operating point and so they cannot deal both with the 'life' and 'death' of the system. They have no basis for autonomous closure for the system, namely what limits the description in space and time from above and below, and finally as M. Eigen has begun to raise the question with regard to chemical reactions, they have no theory for what determines some generalizable 'inertia' in their networks.[1]

10. Irreversible thermodynamics. Thus finally we reach our construct.

Thermodynamics is the only parsimonious 'scientific' construct for autonomous open systems. (Namely systems that are free to move about, with no time dependent driving potentials, and abstract energy and materials from an open source-sink environment, so as to persist in form and functional performance.) Such systems are made up of active like atomisms, that are free to exchange energy. The system description, of both its thermostatic or mean state, and its thermodynamic or changing state, is limited only to those variables which are summationally invariant during atomistic collisions. These variables are few in number. The limitations in thermodynamics is that it can only deal with these or holonomically correlated variables. It can not deal with the artistic 'color' variables of systems, which may represent minor operational differences. Also there is a large and small scale domain of convergence of prediction of its results. Beyond that the system becomes stochastically 'noisy'. However, the description can be used from epoch to epoch with fair (signal to noise) determinacy.

The most compact introduction to our social physics (thermodynamics) is the following essay:

"Social Physics

This note is a brief introduction to a new interdisciplinary branch of physics. It is intended to put that extension of physics and its possible applications into perspective.

Social physics is a science. Practising that science is an art. Let me try to make that clear.

The physics of fluids (hydrodynamics) is a science. Practising that science is an art. Every engineer and scientist who has worked with this field

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[1] Feedback, which can produce dynamic instability, is generally achieved from what is the equivalent of negative resistance structures, as Kornacker has pointed out. These are thermodynamically a physical contradiction - if viewed as systems' elements at the given level. Actually they are active thermodynamic engines procured as deus ex machinas from some other level. Thus our description by the notion of a black box.

knows it. So I'll 'explain' flow physics, to provide both analogue and necessary ingredient to explain social physics.

In flow physics, I need balances in three compartments:

energy balance

mass balance

action balance

Two notes:

While physicists are commonly trained to do the action balance as a momentum balance, it is just as proper, and essentially equivalent to do this balance from action[1] - the summed product of energy and time.

For many problems, the physicist will say the fluid is "incompressible" and so drop any other consideration of the mass balance (Mass, he will say, simply doesn't change). He will then only do a one compartment balance (the action, or momentum balance).

Now, upgrade the problem of complexity to the physics of a society of living things (bacteria; live flies - the allusion being to the notion that physics need not only deal with the motion of dead flies; cows; wheat). Then, one needs to deal with balances in four compartments.

energy balance	action balance
mass balance	population balance

If you conduct such a system, namely if you are a farmer, cattleman, or drug company, you must learn how to deal with these compartments.

I have neglected, thus far, to add an additional idea of the governing potentials which dominate the fields and thereby provide operational boundary conditions.

For the flow field, minimally, I have shared potential of physical temperature.

In addition to temperature, for the living field, I have the potential of a shared "value" system produced by the common genetic heritage of the living system, whereby ensemble members were, in fact, able to repproduce and maintain population - not only as number but as kind.

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[1] E.g., as a principle of least action for nonconservative systems. It is more convenient, for systems with long time delayed internal degrees-of-freedom, to formulate by action rather than momentum.

Now we can introduce the social physics of man. It deals with a give-compartment balance.

energy balance action balance
economic balance
mass balance population balance

The economic balance is commonly viewed as the "account balances" of pure economics, and unfortunately, economists have felt they can do their versions of "social physics" by this one compartment balance. I suggest not. The autonomous characteristics of social dynamics is not economically determinate. Five compartments are needed.

And in addition, we now need five potentials[1] minimally -

physical temperature
an available store of chemically bound free energy
a genetic value system
a shared epigenetic (learned) value system
the rate at which technological innovation, as a productivity gain, whanges and is accepted into society.

It must be specifically noted that you cannot have an operative society without a shared value system.

So - these five balances and five potentials are minimally sufficient to do all sorts of social physics boundary value problems. Good hunting!

And what can you do with the construct? You can make scientific calculations out for three generations in time. What do you need for boundary conditions for such predictions? Knowledge of the past state of the social system for the past 50 generations. Fifty generations will give you three more.

Why is so much detail required? Because human society is not a melting pot, but a mixing pot.[2] Fifty generations worth give you a well stirred picture of the society - the earlier 25 generations are the archaic view of itself that the society holds; the latter (immediately prior) 25 generations are the enculturating process.

There is also the possibility of doing one generation (20 years) calculations. These are not-quite-equilibrium calculations. They are really war-to-war calcuations. For that one must add one more "latent" potential - the potential of a "perceived threat". "

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[1] The proliferation of potentials is not solely characteristic of a social physics. One already begins to find such proliferation in chemical thermodynamics.

[2] It is not usual, in fluid dynamic problems, to characterise the present state in terms of its past history - unless one is dealing with thixotropic fields. Remembrance of things past is the case in social fields.

But the basic notion is that 5 summational invariants must be developed as compartment balances, and minimally 5 background potentials are needed to describe the dynamic balances among fluxes and potentials, and the dynamic transports.

The Thermostatics - Equation of State

As a result of atomistic collisions among the active atomisms, some force bound configurations are captured, and all the moieties settle down to collisional cycles. (See R. Tolman, The Principles of Statistical Mechanics, Oxford, 1938, Chapter I, "Collisions as a Mechanism of Change with Time" for a proper introduction.) Physics identifies the essential properties that are conserved over these collisional cycles. One should note that during these collisional cycles, the fluctuations in these variables are quite large. But within a small number of these collisional cycles, the entire local system of exchanges has settled down to a local dynamic near equilibrium. As many moieties are moving in any one direction as are moving in the opposite direction, so that their mean numerical measures become stationary.

What are these variables that are summationally invariant, even through fluctuating, over the collisional cycles, and what is their significance?

This is the scientific merit of physics in general and thermodynamics in particular. It illustrates why physics is truly parsimonious, not as an analogue description but as an isomorphic description.

For nonevanescent atomistic moieties, there are only three such summational invariants - the conservation of mass, energy, and momentum.

The fantastic consequence of those invariants is that these are the only variables needed to describe both the mean local thermostatic state and the dynamic irreversible laws of motion and change, which we now propose can describe nature, man, mind, and society.

In nature (at least in 'simpler' flow systems, such as liquid or gas flow, the hydrology, meteorology, or oceanography of earth processes; chemical flow systems; the hydrodynamics of stellar and galactic processes; as well as the enabling flows in the biological vascular system), the existence of only three kinds of summational invariants leads to the equation of state, relating mean measures of these three kinds of invariants, which characterizes the 'material' substance of the system, and it leads to the laws of change - how mass species are conserved but transformed, how momentum is transformed in motion and action, how energy is transformed by degradative processes from higher order to lower order.

In living systems of nature, since their atomisms are born, grow, and die, their form has to be replaced. Through a 'genetic' (passed through) code, each generation fluctuation begets the next generation fluctuation. Thus this one added cyclic invariant must exist, not as an individual measure (which leads to a common bar-talk fallacy), but as a species measure. Reliable coding, or rather a physical systems' law for reliable coding is essential for a living species to persist for millions to billions of years. There the conservation of number is the new summational invariant that develops in living systems in

nature.

And modern man has insisted upon inventing one more, out of the abstractions of his head, value-in-trade. Since the beginning of agriculture and fixed settlements, he has insisted upon an abstract notion of exchanging for 'equal' value (which is whatever he so made up in his mind) among the 'goods' of the other summational invariants. And our basic thesis is that descriptions related only to these five invariants are both necessary and sufficient to describe both the statics and dynamics of the social system.

So the fundamental question we intend to summarize now is what is the basic scientific (parsimonious) logic by which the thermostatic equation of state is to be described?

A physical prototype by which the notion of an equation of state is projected to the young physicist is the ideal equation of state

$$p\bar{v} = RT$$

p = pressure

$\bar{v}$ = molar volume

T = absolute temperature

R = universal gas constant

or in measured units

$$pv = \frac{m}{M} RT$$

$$\frac{p}{\rho} = \frac{RT}{M}$$

v = total volume

m = gas mass

M = gas molecular weight

ρ = density

The elementary kinetic model is presented of momentum exchanges of 1/6 of molecules marching toward and away from three orthogonal walls to afford the momentum exchange; of the space between walls making up the time rate at which the momentum is exchanged to develop the force and therefore the pressure in the ensemble, by virtue of a free molecular flight at sonic communicational velocity; and of the temperature as a measure of the kinetic energy of molecules travelling at that sonic communication velocity. Ideal gas law deviations are then presented as due to the finite molecular volumes or to intraaction between the molecules other than at the walls. This then colors most physicists' views of an equation of state, and therefore limits his horizon in extending the notion to other statistical mechanical ensembles other than atoms or molecules. Yet there is a very general notion extant in physics, by which practically all dilute ensembles somehow are characterized by a near ideal gas description, e.g., ϵ/KT (ϵ is an 'activation' energy, and KT/2 is assigned the energy per degree of internal freedom), to provide a background distribution function.

We propose to broaden the horizon.

As a result of physical interactions, of the large scale fluctuations among like atomisms, i.e., their so-called 'collisions', the physical character of their fluctuations is mutually constrained. Thus, for example, for a nonevanescent physical moiety, over any near equilibrium physical cycle, the fluctuations are constrained to

$$A\Delta m + B\Delta|m\bar{v}| + C\Delta\left(\frac{1}{2}\overline{mv^2}\right) = 0$$

Δm = the cyclic fluctuation in mass

$\Delta|m\bar{v}|$ = the cyclic fluctuation in the metric of the momentum tensor, i.e., shown here as the absolute value of the momentum vector.

$\Delta\left(\frac{1}{2}\overline{mv^2}\right)$ = the cyclic fluctuation in energy.

A, B, C, are scale metrics that constraints the linear sum of these fluctuations. They are not necessarily constant.

Namely, we premise that there always exists a computable linear dynamic constraint among the summational invariant fluctuations.

But note that these fluctuations, being cyclically invariant, are locally near equilibrium. Namely the next epoch will result in the same fluctuation. Thus they can be transformed and represented as normalized variables, as ensemble measures, down to the fluctuation size. For example, the last relation can be transformed to

$$A\,\Delta\rho + B\Delta p + C\Delta u = 0$$

ρ = density,(e.g., mass of atomisms per unit volume)

p = pressure (the mean value of the stress-momentum tensor).

u = internal energy (e.g., kinetic energy of atomistic unit volume).

If, for example, we were dealing with living systems, in which near equilibrium cycles require a generation, external momentum is not the appropriate measure of motion but action - the energy-time product spent in various activity modalities -, and we add population density as one more constrained variable

$$A\Delta m + B\Delta|A| + C\Delta u + D\Delta P = 0$$

m = mass density of the population

P = population density

$|A|$ = action tensor (e.g., the action distribution among major modalities).

And finally, with modern man, we add one more constraint - the economics

or pricing or value-in-trade metric.

Now the closure of the problem is simple in theory, difficult (as are all of the accurate equations of state determinations) in practise.

Since the constraint equation holds for each near equilibrium large scale fluctuation, that prescribes the near continuum space and time scale, differential fluctuations can be replaced by differentials, e.g.,

$$A d\rho + B dp + C du = 0$$

and by definition these are now integrable, which leads to an equation of state

$$F(p, \rho, u) = 0$$

Why over the entire range? Because the fluctuations already sampled the entire variable range and guaranteed convergence.

The practical difficulties in achieving accurate equations of state in physics need not concern us now (see for example Hirschfelder, Curtiss, Bird, Molecular Theory of Gases and Liquids, Wiley, 1964). Our problem in this section, is having provided a primitive introduction to the general theory of the equation of state, to suggest, at least at the most primitive level, how the equation of state for a human society is determined. We propose to outline this at a level of primitiveness much like the near ideal gas state of molecular ensembles.

Clearly, as with all near equilibrium ensembles, there is a distribution function in human society. This relates to how basic systems variables are distributed among the population so as to form the mean thermostatic state variables. Prior to fixed settlement, storage of material, and value-in-trade, the human ensemble was much like any other living ensemble. A band of perhaps 20-200 people were bound like a liquid droplet roaming an area of about 1000 sq. mi. (one day's journey by foot in any direction) to satisfy the fundamental compartment requirements - food and tool material, energetics, action modalities (eating, sleeping, procreating, etc.), and reproductive activities. Over equilibrium generation time, their energetics was represented by a dissipation (and acquisition) of about 2000 Kcal/day, an energy balance achieved by hunting-gathering acvities among plants and animals with nearly a uniform energetic expenditure for all individuals (with some modest division of labor), via the cyclic ingestion or turnover of oxygen, water, carbon dioxide, carbohydrate, fat, protein, minerals, and some trace elements. The life expectancy was about 30 years or less, out of a potential life span of 90 years. A considerable number of debilitating factors contributed to the short life, but it is quite possible that marginal food availability was the major limitation. Birth rate, conducted largely by outbreeding and splitting off to neighboring populations, was very slightly above replacement rate. Storage was negligible. The only thing that marked this species as man was the near constant rate of technological advance made possible by a mind capable of abstraction, speech, and memory in the development of tools and activity modes (e.g., patterns of housing, hunting, and organizing activities).

We have thus described the paleolithic thermostatic state.

Proof? Send any group of men and women out to a new territory, and note that they will organize their activities around these predictable bounds. The level of technology they will assay depends only on their epigenetic memory (of what they were taught) and materials available where they go. That kind of experiment has been done and can be traced retrospectively in many ages in the past. The only thing lacking is a statement of the rate at which technological complexity will be found advancing in the 'new' civilization. But that can be estimated. It is a question of what sort of division of labor members of the group have been trained in, and how much real epigenetic training exists in the group. Given that, most technical people could estimate, by generations scale, what sort of diffusive evolution of technology might be expected. Results would be meaningful at the 3-10 generation level.

So now we turn to modern man, with value-in-trade. Fixed settlement, yearly agricultural capacitative storage, and large scale convection, change the field stability of the society. Now more formal molecular associations with a greater diversity emerge to satisfy diverse momentum (action) functions. Also two classes emerge in society. In the primate society from whence man came the boss monkey leadership was common. Now, it appears in the form of an elite, a group still perhaps of 2% of the family population, who mobilize and control 'power' (the product of the number of people and the daily energy that they pass through). Such a two class distribution is independent of the political or economic system and will never 'wither away' as long as man is genetic man and mann uses fixed settlements and storages.

The operational molecularities (e.g., cohesivily tied as groups of perhaps 10-100) are:

hunter
trader
scavenger
procreator
deus ex machina ('organizer')
gatherer
pastoralist
agriculturist
raider
cog-in-the-machine
artisan
cognitor ('intellectual')

It is with these diverse social molecularities that the social structure of modern (post-Neolithic) man is organized. The social canvas of his societv is spread spatially through a particular spatial ecological milieu - each 'state' society to its own territory. The character of agricultural-industrial[1] exploitation is based on ingathering into trading, storing, and producing centers

[1]There have been technological 'industries', e.g., tool making industries for a much longer period than modern post-Neolithic man. But it is the 'new' competition of agriculture and industry, in fixed settlement, that marks the modern post-Neolithic era.

(urban centers) and a more uniform distribution of agricultural activity. That pattern is spread throughout the space, with more or less characteristic distributions. The molecularities are roughly constrained to their life-supporting center, except for those who 'convectively' roam the space (e.g., traders, raiders). We will say more about the spatial form later. Now, we are only concerned with a lumped - completely aggregated - description of the entire 'autonomous' state moiety.

Activity in the concentrated centers (urban areas, total organized state) is directed by elites - the dei ex machina - who act catalytically to raise the operating power level of the social system. They mobilize people-energy. In the earlier pre-settlement form, they were the 'boss monkey' primate leader. Now, in organized molecularity forms, they represent those families that rule and direct the activities of other families. The essential ingredient that makes the governing task (in a technical sense) possible at a higher-than-primate level is the modern brain of man, which permits a historically evolving epigenetic heritage of technology. That technology provides an increasing power gain. It is that technological power gain - a 'negentropy' potential - which permits the higher power operation of the society, and which in fact permits operation where the populace can support the elite. It is fixed settlement, and agriculture, with storage capacitance and convective trade, and value-in-trace that makes the amplifying role of the elite possible.

How are we to see the elite? As with all statistical mechanical ensembles, there is a basic distribution function, e.g., the stationary Maxwellian distribution of kinetic energies among molecules in a gas.

In the human social population, one finds a similar distribution function. This can be illustrated, for example, in annual family income, or total family wealth, or other measures in each of the compartments as one finds them distributed among the population.[1] The intensity of population is distributed near normally with annual income. But there is an extremely long 'hidden variable' tail, whose intensity is not detected unless one expands the population scale logarithmically. That 'hidden variable' tail covers a very small percentage of the population, and has always covered such a small percentage. The operational solution has nothing to do with political systems, or even human or living social systems (although the population level of the tail may change) but is an intrinsic characteristic of thermodynamic engines; it is truly the operative 'hidden variable' (in the sense of David Bohm).

To understand thus, one must touch on circularly causal systems. These are not feedback systems. They are circularly causal. A causes B. And then B causes A. As a result, a cyclic process persists until either end breaks down, or external causality interferes with the operation.

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[1] The distribution for a molecular ensemble, e.g., gas in a container, is not only the statement that energies are distributed Maxwellian, but also an equal occupancy in each volume region, and the tensor distribution of the momentum. Thus all compartments need to be specified at the atomistic level of the population.

Examples? The rudimentary theory of the clock suggests that an autonomous harmonic oscillator will keep time. It will not. Because of thermodynamic losses, it will run down. A high frequency escapement nonlinearly releases energy impulses. This impulse occupies a very small phase of the time keeping cycle to restore the losses. A nonlinear limit cycle process is entrained. This is a first elementary illustration of fast processing and slow processing.

Actually this same 'squirt' system is the basic foundation of all biochemical systems' operation. 'Glands' impulsively express chemical messengers of pharmacological dosage levels which degrade to provide the mean low physiological operational level (which may include various chemical transduction steps).

But even more telling and more basic is the operational level of a molecular ensemble. It is the radiation exchange field operating at incredibly fast rates, not the much slower 'elastic' collisions, that keeps the ensemble in motion. Here we really track the fast process-slow process circular chain down to its real lair.

At the present time, it is not possible in the science of physics to resolve the basis for fundamental quantization in systems. Thus explanations rest at the level of quantum mechanics - a dual theory in which Newtonian-Maxwellian-Einsteinian mechanics are valid and a quantization process which entrains and locks the process into fixed orbit. We prefer to think of this process as a nonlinear lossy (thermodynamically consistent) process. We use David Bohm's notion that there must be a 'hidden variable description', which we have suggested is a circularly causal escapement that nonlinearly runs the process.

The idea has received more strength, at a foundational level, in the published works of T. Boyer who has provided a quite classical foundation for quantization.

Beyond quantization of the atomistic level (i.e., a basis for Planck's action constant h), there are growing nonlinear theories for quantization of higher organized systems' levels. For example this has been shown in the hydrodynamic field (Taylor cells; Bénard cells; we have contributed models to pipe turbulence).

Thus in our opinion, with various degrees of hard physical proof, it is the basic nonlinear operative dynamics of coupled systems that require pulse-like escapements for their operation. This class of notions has been also developed by Prigogine.

More generally, it must be looked at as the basis for catalytic processes. Namely, a catalyst, by itself cannot change the final concentrations of reactants in a solution; it can only change the speed of reaction. However, if the catalyst is caught up in its own thermodynamic engine chain, it can then produce a properly timed ('negative resistance') active circuit element that can change the operating levels in an autonomous system.

So when we move up to man, neurophysiologically we find that kind of competence emergent from the coordination centers that become the basis for language and abstraction (coupling of otherwise incongruous signals). And when we move up to modern human society, that kind of internal driving can be put

into resonance by some individuals. These are the elites - the catalytic dei ex machina, the squirt systems. A priori, from the characteristics in all other systems we are familiar with, their required number or temporal processing levels, to govern the changed stability of the systems they dominate, is a few percent. Empirically, this is what we find in the social tail. And what we are saying, as in all systems, you cannot have a larger elite occupancy of attention because they would become chaotically unstabilizing. So it always is a 'winner take all' process, namely there is some rate governing process that wins out. We are indebted to Eyring's writings for this kind of notion.

In primates, the nominal boss monkey rule is perhaps[1] in 25 (e.g., 10-50). In humans it appears that about 2% elite family govern 98% populace families.

What is the balance by which the system works? The elite take approximately 50% of the total income produced off the top. Out of that income so produced - which can be roughly viewed as 25 populace families supporting not only their own requirements from half their effort, but also donating half their effort to a single elite family - the system runs at some level above subsistence.

While the following themes tend to generate considerable intellectual heat, we are not engaged in writing ideology, politics, or philosophy, but in describing the operation of a very complex system.

Without such catalytic operation, the human social system, as with all other living social systems, would operate near the margin of subsistence. That is how man operated as hunter-gatherer. The effect of settling and capacitative storage has both precipitated elites and raised the average living levels. Instead of operating at the margin of subsistence, the median operating level is twice the level of subsistence. It is true that the distribution function is embedded at its low end of the margin of subsistence. Systemsoperators may attempt to argue whether that low end can be raised. We think not. We think it can be improved,[2] but not removed from that level.

But, for that factor of two boost, there is a charge. It can be seen in the average income which is more nearly three times the subsistence level. That

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[1] While we may be the first physical scientists to have arrived at this notion from physical stability arguments, we are not the first to grasp the idea. Aristotle is responsible for the western summary of the state as the rule of the one, the few, or the many. Sereno, The Rulers, Praeger, 1962, presents very well the discussions that past thinkers, e.g., Pareto as well as Marx, have contributed to the notion of elites. For example, Sereno offers the basic observation of Mosca (1884) that "In all societies - from those that are very meagerly developed and have barely attained the dawnings of civilization down to the most advanced and powerful societies - these classes of people appear - a class that rules, and a class that is ruled."

[2] We have the examples of the most advanced nations in the world. To cite an illustration, consider Sweden's program. An excellent example of their progress is contained in an article, "Sweden Proposes Eased Retirement", N.Y. Times, Oct. 26, 1975, Sect.1, p.8.

difference between the median and mean income buries the hidden variable charge that the elite make to catalyze the system.

Contrary to the Marxian notion that the workers are unfairly taxed in their labor for the entrepeneur's profit, there is the more basic notion that the elite - regardless of the political system - put a charge on the system, both to provide them incentive and the wherewithall to excite the system to run at 3 times its minimally required level.

How can this process take place? It is not difficult to understand, if the five compartments are examined, and the five added potentials are understood.

The human requires some minimum daily caloric intake of somewhat under 2000 Kcal/day for idling survival. For balance, he has to operate, by doing external work, at some higher level at which income equals output. (If not on a daily level, it must so average out in very few days). While he can operate at equilibrium values up to 25,000 Kcal/day, generally it becomes debilitating and life shortening to operate about 6000 Kcal/day. Comfortable operation is in the 2000-3000 Kcal/day level.

Most animals have a productivity greater than unity. Namely, they do not have to work all day uniformly to produce what they need for survival. Thus their activities are then distributed among the actions that their genetic and (among some animals) their epigenetic value systems incline them toward. Selection pressure on their genetic mutations selects those animals for survivorship whose actions best fit survival.[1]

Thus the notion of paying a tax on one's production is not strange. And in fact the animal family life illustrates that the division of labor of procreation wherein both parents contribute in some way to supporting their offspring shows that a family can produce enough for its survival without all working uniformly. Conversely, animals regulate their family size (or their group size), so as to be able to survive.

In pre-Neolithic man, family size was quite regulated on the slim side.

But, with fixed settlement and elites, the ability for a 'family' to contribute a limited percent (e.g., 5%) of its produce to an elite was not out of the question. Thus 'taxation', at the level of 5-10%, has always been possible. Rebellions and times of troubles take place when the taxation is very much greater. Thus 25 families supporting 1 family is not so burdensome.

And what does the elite do with that support? First they conduct their

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[1] This is not tautology. Living systems entrain thermodynamic cycles of operation. If there were not a genetic code, generation to generation survivorship would not be carried forward. If the code were not mutable to select survivorship, some disturbance would have wiped the existing living species out. Mutation in the genetic code provides for capability to incorporate the disturbance into a way of life.

family existence at perhaps 8 times the margin of subsistence. The rest they invest in productive facilities.[1]

The remnant variables are the total population in the state, the size of the state, the size of the family, and the operational level of productivity.

We may start the discussion of causality in the social chain from the latter factor.

The hominid mind has had the capability of learning, memory and evolving 'tools' - things which were not self or outside world, but which could be applied between self and outside world to affect his own motor extensions. Namely tools could provide a power gain. That increased his productivity past simple gathering and hunting with his body's motor systems.

With man's genetic heritage, the rate of such technological productivity gain increased. Once he settled into place, one finds essentially a linear increased in technological complexity ever since.

Why linear? Because each generation can add about as much increase in technical complex as the previous generation. They are both rate governed by the abstract ability of human mind.

Productivity, as a power factor, is roughly related to that gain in technical complexity. Thus in each epoch we have some culturally determined technical complexity, an associated productivity, and some expected rates of increase of both complexity and productivity for the next few generations.

That level of complexity and productivity basically determine the family size. An agricultural based state, at the turn of the century, required more children in the family than the industrial-agriculture state of today. What were the children for? The family was the minimal unit that could procreate and maintain a survivorship above the margin of subsistence.

The chain becomes circular at this point. At the existing level of technical productivity, there must be sufficient product that will permit the elite to maintain the operating level of technical productivity by investment.

Thus the elite is constrained in the value-in-trade 'wages' he pays out (or permits the populace to keep). That level of 'wages' - tied to the productivity - determines how many people in the family have to work to achieve the margin of survival for the entire family (or as we have suggested, twice the margin of survival in these coupled systems). Actually the determination of family size is at the margin of survival. And then, since the society shares a common value system and perception of itself, in the main the rest of the populace, including the elite, have a comparable family size.

These notions lead to a local equilibrium. They do not determine the nation size or the population.

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[1] In socialist, communist political systems, instead of 'owning' the surplus investment for productive facilities, the elite only 'control' it.

The potential pre-Neolithic settlements were contiguous 1000 square mile areas with perhaps 50 people per area (one day walking radius). Post-Neolithic settled man was still confronted by the friend-enemy inbreeding-outbreeding theme. Thus settlements can be imagined as making up a latent network of settlement foci arranged like a near crystalline lattice of 25 mile separation. These foci were potentially capable of conducting a near balanced social system. However, the modest lack of balance in all compartments, the price paid for fixed settlement, could be made up in a trading constellation of perhaps 20-30 such centers, namely by a 100 mile by 100 mile domain. This may be taken as an idealized notion of a 'civilizational' moiety.

The actual form that these organizations would take now begins to depend on local potentials, e.g., ecological, geological, geographic. Namely, at any particular stage of technical complexity, the winners in the local communities (both the community and the elite molecularities within each community) develop. This step may appear mysterious and indeterminate, but it is really not.

Before we discuss that 'deterministic' component, we have to touch on the less deterministic component.

What is the political form and extent of the organization? That is less determinate. It depends on the ambition of particular elites in organizing and conducting wars.

The large scale, long cultural heritage, of the people (25 generations) and of other people, from whence come potential raider elites, determines the form of political history and evolution. At this level, we can only say that the civilizational constellations form and fragment at the 500 year scale. Thus a theory for the long range forms need not concern us in this study. We need only deal with the one generation war-to-war process scale. And that emerges from the 'perceived threat' potentials of those moieties that are bound into trading constellations (including both traders and raiders).

Thus the ruling elites, besides having to concern themselves with these compartment balances, have to include within the action balance the ever present possibility of war and defense. Thus a well known list of institutions develop in these societies, which provide the frozen out form by which function is achieved. Defense and warfare become a major component of the organized moiety.

Now it is possible to indicate how all of these compartments are effectively deterministically filled at a few generation time scale, short compared to the civilizational scale.

The land is a two plus dimension field upon which process of social life unfolds. Generation by generation, men probe at the land and determine how it may satisfy the conflicting demands among the five compartments - materials, energy, population, action, value-in-trade. The potential capability of the land, given a relatively fixed climate and geography, doesn't change rapidly. Thus, for example, one can surmise the form that equilibrium ecologies would take upon the land.

Man is not tremendously different. Thus one finds a distribution of func-

tions that remains very slowly varying functions of time. Thus the utilization of the land, for a given complex technology, is largely representable by a generalized 'carrying capacity'. Thus technical productivity finally even fixes the population level. Because of the extreme growth of population of the past 200 years, there is a somewhat uncertain search in scientific circles for a theory of population.[1]

As an alternate to demographic theory, the following essay expresses a different class of governing nations:

"The Malthusian Concept Revisited

The problem

As the Twentieth Century enters its final quarter, it seems quite strange that, after 200 years of the greatest expansions that human society has ever seen, - in population, in energy utilization, in food production, in materials utilization, in the economic standard of living and the potential conquest of hunter - there is such a growing disquietude about the future human prospect. This uncertainty is not only to be found among the underdeveloped nations who are concerned whether there is any way they might reach a takeoff point toward an improved life condition, but also among the leading industrial-agricultural nations who are uncertain whether they can maintain the gains they have made. We propose to offer a scientific note that will try to bring the problem behind the disquietude into perspective.

Two applicable scientific principles

I. Any ensemble of interacting individuals, whether consisting of physical or human atoms, very quickly come to a local dynamic near-equilibrium. The statistical mechanics of their interactions assures one that in 3-10 collisional cycles their dominant variables will relax to near equilibrium. The physics of dynamically interacting ensembles is drawn from so many different binding configurations that one cannot be surprised at the tremendous range of cyclic time scales that may be involved. Atoms in a gas start and stop their relaxational processes in 10^{-10} seconds. Weather, in the atmosphere, breeds its changes at the order of weeks. On the other hand, humans replace each generation in perhaps 20 odd years. The earth process scale to raise and wear away mountains takes 100 million years. The birth and death of stars may be measured in the billions of years, and the universe may exhibit a cycling scale at perhaps a hundred billion years.

II. When an ensemble of interacting individuals is allowed to expand into a new domain,it 'quickly' (at the previously prescribed time scale) relaxes to near local equilibrium. Materials, energies, activities, reproductions, monetary flows will all become established by accommodating to the available open stores in the environment. In addition to the individual-to-individual interactions of statistical mechanics, there may arise large scale nonlinear convective patterns - the analogues to the vortex structures of flow fields which make air mass movements, or turbulence or galactic filaments. These are thermodynamic

[1] See for example, M. Teitelbaum, "Relevance of Demographic Transition Theory for Developing Countries", Science 188, 420, May 2, 1975.

engine processes which carry energy cyclically among sources and sinks in their local open environment.

The implications in these two technical ideas

We are concerned with what happens to a living species when it is injected into a new domain. The expected thermodynamic notion is that if there are ample sources and sinks of potentials, the species will grow in number to achieve an equilibrium.

But many species, in particular man, have continued to grow. Hos is this to be explained? It would seem that the fundamental way, after a first initial expansion, is by drawing upon the nonrenewable resource of its source and sink potentials. Let us try to elaborate on this notion.

The sun, in billion year time scale, is a nonrenewable resource. Earth's geochemical processes, responding to that resource, ultimately developed the forms of biochemical life processes. As a result we have seen a biomass growth on the earth, at such long time scale. The growth rate, past start up of life processes, is quite slow. One surmises that it has or will have peaked and the level of biomass will ultimately decline. Yet locally, at all times, the processes are near equilibrium.

But that is not the time scale we are now concerned with. At the time scale of man - his hominid ancestors having lived for the past few million years, he having existed in his present genetic form for the past 40,000 years, 30,000 years as hunter-gatherer, 10,000 as agriculturist, 200 as agriculturist-industrialist - the sun is a fixed benevolent potential, and photosynthetic conversion is its large scale steady-state process that provides living systems with their copious stores of free energy.

Fixing our view on man's time scale, one finds population growths - small for his hominid ancestors, growing with modern genetic man, and positively explosive with man in the past 200 years.

Take note that 200 years ago, Malthus pointed out that living species grew geometrically by doubling (division), whereas photosynthetic food resource grew linearly (in proportion to the amount of land resource made available). Thus ultimately a food crisis, or, as we believe he really meant, a leveling off of population to an equilibrium would have to occur.

And in fact, in the succeeding century, by the work of Verhulst, Pearl and Reed in the U.S.A., and Yule (in the 20th Century) in Great Britain, logistics theory suggested the character of the local community's leveling off of population.

However this explanation left a paradox as to why population overall has continued to grow, even if leveling off in particular communities.

We submit that one ought to think about the problem in the following way. Man's hominid ancestors were already beginning to make use of a nonrenewable resourse (i.e., tool material) at a rate faster than earth processes would reproduce it. . Thus their population could grow, albeit very small. (Of course,

their population was so dilute that, while the process may have limited their growth, it furnished no particular geological burden on the earth. Current processes do.)

Man, as hunter-gatherer, began the process more intensively. And in most ways the correlation between man's historical growth in population and the number of artifacts found (corrected for the degradative relaxation of material) is a direct essential measure of that process.

But the real explosion, when intellectual technology reached the state of being able to exploit the process, took place 200 years ago with the fantastic exploitation of nonrenewable resources that marked the industrial revolution.

There has been considerable controversy over the cause of the population explosion from that time on. We are proposing what seems to be a more fundamental explanation than that simply related to the potentially larger population that the factory required and that a higher level of agricultural productivity permitted. More basically, it is the consequence of forcing nonrenewable resources through a cyclic chain with high productivity exploitation of those materials that supports a population growth.

Now, (give or take a few generations) we have exhausted the easily available stores of nonrenewable resources. The basic disquietude that the world has is an 'unconscious' realization of that fact. The end of a 200 year explosion in population is in process, and it makes all social participants uneasy.

The problem we all face - locale by locale, state by state, nation by nation, in international unison - is whether we are prepared to make rational adjustments to the future or whether we will meet the future in our usual disruptive skin-of-our-teeth natural course? While we have begun to write scientific programs on how to achieve a rational regulation, we are not sanguine of achieving any results. Thus, we fear once more we must be exposed to the Malthusian themes before the future is thrust upon us."

Even though a world wide population explosion took place, the social system operates near thermodynamic equilibrium. Thus the potential curves that govern the American development across the continent are quite slow varying,post start up.

Thus, we propose it is possible to outline the American experience by potentials for population, materials production, energy consumption, the productive activities of both men and machines, and the storage and annual flux of value-in-trade. When these are each suitably normalized, they become essentially time invariant, so that they can be used for future predictivity.

On one hand, as we have very lightly outlined, they lead to a notion as to how the aggregative normalizing factors can be theoretically correlated in a lumped equation of state. (Namely how population and materials utilization, and energy, and current productivity, and income, and family size are interrelated - both now and for the next three generations. Or if the perceived threat potential is also taken into account, one can make estimates of 1 generation fluctuations.)

Now these potentials can be applied to determine the large scale fluxes; e.g., the transports and creation of material, energy, population, value-in-trade, and new technological activities. The problem is very much akin to conventional steady state hydrodynamics.

The Thermodynamics - More Localized Processes in Time and Space

Note, what created the large scale social field, i.e., the U.S.A. as a nation, was the atomistic diffusion of people and their energetics, their organization of social molecularities, and their precipitation into a latent network of communities. The systems organization of these social forms implies both a time scale of processes and a space scale.

Thus what one finds superimposed on the mean state of the large social system (and in fact the fluctuations that make up the social system) is the following major coherent processes: The daily time scale - as a living system, man's circadian rhythms trap him into an entire complex of social rhythms at the night-day scale.

The three day scale, or its subharmonic, the social week - for physiological reasons, that are beyond the scope of this contract to elaborate upon, man is driven with a strong 3 1/2 day rhythm, likely hormonally derived (thyroid). It appears that the social week may be its specific expression. Nevertheless, there is a coupling between the large scale sensory-perceptual system and the reactive motor-planning-executing system which expresses itself at perhaps half week rhythms. Thus planning of social functions, in particular transport functions, had best be responsive to half week-week rhythms. From a nonlinear dynamic view, it is an appropriate scale at which a dithering dynamic regulation of the higher frequency daily scale might be expected.

The 30-60-90 day, near seasonal scale - again for physiological reasons, which are poorly understood, there seems to be a major biochemical regulation at the approximate 60-day scale. To a large extent this tends to be entrained socially between two prominent processes - the female menstrual cycle of near 30 days, and the temperate zone season.

The one year scale - Climatic variation, particularly in temperate zones, tends to become a dominant signal at this time scale. Seasonal growth dominates this scale to make it the most central social process time.

The 3-4-5 year cycle. Similar to the 3 1/2 day hormonal cycle, there seems to be a strong nonlinearly entrained 3-4 year decision process. It is very likely that we have locked in our political process around that scale, which may or may not be desirable. Namely, it may 'potentially' accentuate a dynamic process which should be noted in passing with only a little energy, whereas we have begun to do a lot of decision maing at this scale.

The 20-25 year generation time. This again is biologically determined by the human growth to reproduction cycle.

As we have suggested, these 6 process time scales provide the essential kinetic fluctuations that relax to the 3 generation thermodynamic equilibrium.

And therefore, beyond a thermostatic characterization of the mean socio-economic state of the society, a systems model has to deal with the spectral characteristics of these six process times. That planning and the required data base are based on the known characteristics of the human. One can postulate a physiological-psychological man who operates with about 20 action modalities and thereby distributes his action through the day. There is also a reasonably acceptable distribution of action-time characteristics that fit human beings. Thus one can model and identify kinetic and transport processes and coefficients by way of these known modalities.

But beyond identifying the process time scales, the modelling also has to identify the spatial scales of the field.

The latent schema of population centers, via the strong convective processes that become driven by storage and potential differences, deform these into a slowly changing series of urban settlements.

Again ecology, climate, geography (e.g., topography) tend to determine these centers. Thus the potential diagrams for a large scale socio-economic moiety already show the local deformations and singularities that make urban areas.

All of the potential forms that have been suggested for the large scale moiety, are also to be found for the smaller localized urban moiety, albeit with some greater fluctuational character.[1]

But it is here that the more modern dilemma ('modern' in the sense that it has been characteristic for the past 6000 years of growing intensive urban settlement) has arisen. Past some early start up phase, the urban singularity does not have the potentials to support a large population density. Thus, even when 'provincial', it served as the storage and trading center for a larger central locale. But, immediately, this poses the conflict between local 'provincial' interest and interest in a larger trading domain. The conflict is always between the notion of a local elite who can control people power locally or use local power for more advantageous remote or 'foreign' adventure. The urban area is thus automatically and deterministically caught up in such dynamically unstable dramas.

While there may be some 'political' distinction between an eastern mode of production (in which the urban area is ruled from external central authority) and a western mode (in which the urban area possesses more autonomy, with sufficient strength to withstand remote central authority to some extent), in the end there is no way to avoid the dilemma that the urban area is a dynamic functional form, rather than a fixed form for all times. Its complexion changes considerably at the 3 generation level. And it undergoes serious alterations at the 20 generation scale.

But that then poses the problem that any policy maker, socio-political operator, or systems designer faces when dealing with urban systems' institutions. They are not fully autonomous, they are responsive to the currents in the larger state moiety.

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[1] See for example, P. Gould, R. White, Mental Maps, Penguin Books, 1974.

If we grasp the notion that not only does the man-system operate with about a 3 generation time scale (70 years), but that other materials (e.g., mineral and floral derived structures), as well as the faster earth processes (weather, flood), also exhibit their life systems characteristics in that same time scale, then it is possible to arrive at an urban systems' strategy and model for its institutions.

One must recognize the strong governing significance of the war-to-war generation effects[1] on a state moiety. The urban area must model its balances for the periods from war to war. It may use the notion of the perceived national threat to achieve some measure of the tenor and epigenetic value system that affects its people and their elite (including the political process).

With a 3 generation near equilibrium program in mind (namely, what might be expected as the next full process relaxation - in population, technological productivity, materials, energy, value-in-trade processes), the urban area should model its potentials and fluxes and the growths and changes it may be able to make for the next generation (20 years).

Such modelling, being geared to the likely effects of 3 generations, has the highest chance of being realized. Namely, if a standard central tendency program is designed that takes into account the daily, weekly, seasonally, yearly, 3-4 yearly, and generation fluctuational processes, and some measure of their dispersions (for both the populace and the elite classes), then a model system that is isomorphic with the urban area will be achieved, and it will be found that the system is controllable.

Conclusion - How to Develop a Systems Model for Transportation

1. Develop the potential curves appropriate to the 5 compartments for the central political establishment (nation) for its past few hundred years of near equilibrium.

2. Using the past as a retrospective study laboratory, trace the technological development of the transports' systems that provided the flux balances for these potentials over the past few 3 generation time scales (e.g., 1830, 1900, 1970). These transports are for materials, energies, people movement, population growth, people activities. Note that the operational time scales are balances at the scale of

1 day, 1 week, 1 season, 1 year, 3-4 years, 20 years.

3. For any particular urban area, or for a composite of urban areas (e.g., for urban systems), develop the potential curves appropriate to the particular area with its much more localized detail. Develop the flux patterns.

4. In particular, note very carefully the dispersions of fluctuations for each generation over the past few relaxations. (For example, any large American city has had to alter its transportation views for the intervals Civil War -

[1] E.g., Revolutionary War, War of 1812, Mexican War, Civil War, War with Spain, World War I, World War II, Korea, Vietnam.

Spanish-American War, Spanish-American War - World War I, World War I - World War II, World War II - Korea, Korea - Vietnam, Vietnam - ?. These fluctuations were dealt with more slowly by institutional changes, more marked by epochs such as post Civil War (1870) to pre World War I (1910), World War I (1920) to post World War II (1960). The design problem now is the post Vietnam War (1975) to ? (2010-2040).)

5. Modelling then consists of working out a systems balance for the various time scales named prior. For example, we believe such study for the next few generations at existing or perceived future levels of technology are faced by the problem of a transition toward nonrenewable resource curtailment, a process to be seriously encountered on a large scale for the first time in 200 years. (It was common in other periods of time, so the theme is not absolutely new.) The balance modelling should show that; or else it should show to what extent some expansions are possible.

We also believe that the marginal balance of many urban centers in the U.S.A. today requires an intensive redirection of technological thought - not to less technology, but to a more sophisticated technology to do things with renewable resources and with greater efficiency from existing resources. There are other alternatives, some of which may be acceptable to a nation with a particular value system, others not. For example, genocidal abolition of population is likely not one such solution, even though it has often been used in history as a nation and city regulator. Our a priori estimate is that cities will require rearrangements and the development of a considerable amount of new industry that tends to make them locally more self sufficient. It is likely that the urban-suburban disparity will have to be abolished. In passing, one must note that besides the technological steps of turn of the century refrigeration and automotive transportation, governmental programs were quite influential in developing the urban-suburban disparity. Thus there is as much reason to believe that government can influence its abolition.

The question of whether it needs abolition or not is not to be decided by bar-talk combats, but by what costs the compartment balances of the future show. Clearly many urban areas are approaching saturation breakdown (Not to be measured by the good days, but by the number of bad tie-up days). The purpose of these compartment balances we have developed is to exhaust all of the essential variables in the social system cycle.

The dynamic constraint on solutions is what the latest potentials are and what conductances can generate the needed flux balances. We don't believe that there is very much more looseness possible in many of the urban systems.

What is the Necessary Data Base?

We have suggested the necessary data base. Information is required on population, 'food basket' requirements, land use requirements, materials, energies, value-in-trade balances, productive activities, technological developments, markets. Data must be in hand for the aggregated balances of the particular sociopolitical moiety and how they are met, as well as the regional potential distributions on how these balances are affected.

How to Develop and Test

We have succeeded in transmitting many of these ideas to TSC Systems personnel, and a very preliminary form of developing these socio-economic potentials has been begun.

We have also outlined a control scheme (Ziebolz two time scale controller) for urban areas. This includes high frequency systems operation of daily scales as well as low frequency policy making at generation scales.

We have developed an ideal systems model basis for both a long term national transportation system as well as for urban systems.

In our view, TSC personnel should take those pieces out of our modelling that they believe to be implementable and that they wish to develop and test further. On the other hand, with their guidance we believe that we should be allowed to continue to develop any or all of the modelling foundations we have begun with greater detail.

The testing of these models can be done as follows:

First, the near stationarity of the socio-economic potentials, in history, should be ascertained.

Second, the ability to predict the fluxes from these potentials should be demonstrated for past epochs.

Third, the control scheme we have outlined (Final Report Part I, Part II) should be developed in an open loop fashion, at least to the extent of encompassing the transportation system for an urban area or the nation. Its ability to represent and give the same response as the urban area, with only moderate changes should provide a test for our high speed analogue modelling of the system.

In Part One of our final report, we touched on an earlier study[1] in which we related the characteristics of the earth's river system very tightly to the earth. Rivers fit the land, and the characteristics of rivers could be referred back to and estimated from the characteristics of the land.

It is a most remarkable result of this study of societal man that man's social characteristics are tied just as intimately to the land. And we have succeeded in taking the first step to tie his social thermodynamic characteristics to the land and its potentials.

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[1] A. Iberall, S. Cardon, H. Schneider, "A Study of the Physical Description of the Hydrology of a Large Land Mass Pertinent to Water Supply and Pollution Control", 4 reports to Div. Water Supply Poll. Control, Public Health Serv., HEW (Div. now in Dept. Interior), Contract NO. SAPH 78640, 1961-1962.

APPENDIX - REPORT OF INVENTIONS

The work performed under this contract, while leading to no new invention, has led to several innovative concepts on the use of near equilibrium thermodynamics for living social systems. Compartmental balance of food materials, energetics, manpower, productive function, economic balance, and technology were introduced as concepts for social systems modeling, as well as the idea of summational invariants for social systems.