

ACTOR NETWORKS, ECONOMIC IMPERATIVES AND THE HETEROGENEOUS
GEOGRAPHY OF THE CONTEMPORARY POULTRY INDUSTRY

by

MITCH CHAPURA

(Under the Direction of Andy Herod)

ABSTRACT

The relationships between science and capital in the contemporary poultry industry are theorized from an Actor-Network and Complex-Systems perspective. Regulationist approaches are criticized for employing functionalist reasoning. An empirical examination of funding and research patterns in the University of Georgia's Department of Poultry Science is offered to illustrate the potential of this novel theoretical perspective.

INDEX WORDS: Poultry, Science-studies, Marxism, Regulationism, Actor-Network, Complexity, Scale, Geography

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CHAPTER ONE: Of North Georgia and Avian Domesticates

Introduction: "The Poultry Capital of the World"

The meteoric development of the poultry industry during the latter half of the 20th century has dramatically transformed North Georgia's cultural, economic, and ecological landscape. The thousands of chicken houses visible from the air¹ attest to the industry's tremendous importance in the region. A full one in sixteen Georgia jobs is poultry-related. In 2003 over 5 *billion* eggs and 1.26 *billion* broilers (young chickens raised for meat consumption) were produced in Georgia, worth an estimated \$2.55 billion. The state has surpassed Arkansas to become the leading producer of broilers, accounting for 15% of U.S. output, which is no small feat, given that the U.S. produces more broilers than any other country on Earth (Fowler 2004). To further put this in perspective, if Georgia were a *country*, it would be the fourth largest producer of broilers in the world, behind only the U.S., Brazil, and China. The Georgia House of Representatives was perhaps justified, then, when in 1995 it passed a law officially designating the State of Georgia the "Poultry Capital of the World" (Weinberg 2003).

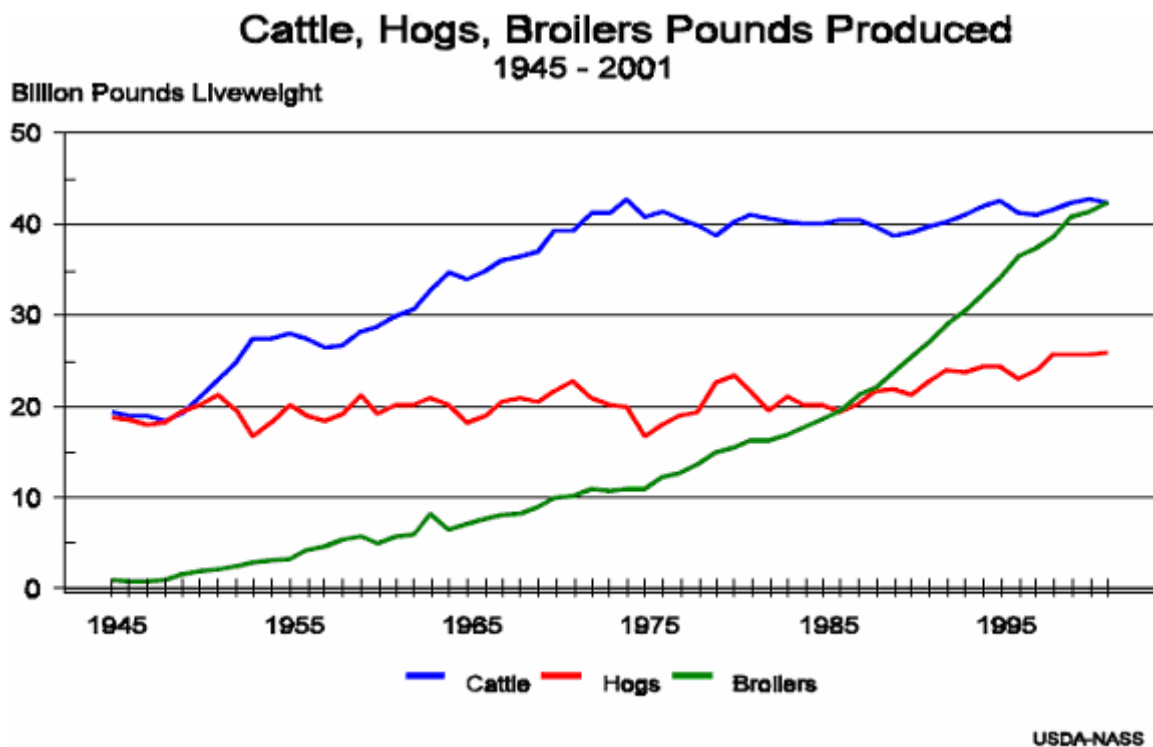
While the growth and magnitude of poultry production in North Georgia is especially impressive, it is not anomalous. "Between 1950 and 1999 U.S. production increased at an average rate of 7 percent per year to over forty billion pounds, while real prices declined by almost a third" (Boyd 2001: 634). In 1945, 366 million broilers were produced in the U.S. By 2001, production had increased to 8.4 billion (USDA 2002). In 1991 U.S. per capita chicken consumption exceeded beef consumption for the first time (Watts 2000).

¹ This contrasts with the ground, from which the presence of chicken houses is often sensed first by smell and only later by sight.

In 1945, broiler production was 1.11 billion pounds live weight, compared with 19.52 billion pounds of cattle and calves, and 18.84 billion pounds of hogs live weight. In 2001, broiler production was 42.45 billion pounds, slightly higher than the 42.37 billion pounds of cattle and calves, and well ahead of the 25.94 billion pounds of hogs and pigs (USDA 2002: 1). See figure 1.

The average American now consumes more than 80 pounds of chicken a year (Boyd 2001). Globally, poultry production has risen more than six-fold since 1965 to over 65 million tons, a tripling of per capita supply. This growth exceeds that of all other animal meat sources (Zhang 2002).

Figure 1



Source: USDA 2002

As global demand has increased, particularly from Russia, China and Mexico, so has the importance of poultry exports to U.S. producers. The U.S. exported \$1.8 billion

worth of poultry products in 2001 (Zhang 2002), with Georgia alone accounting for \$308 million (Weinberg 2003). All of this production for domestic and foreign consumption, however, is not without its drawbacks, the most obvious of which are ecological. Chickens produce 1.46 million tons of poultry "litter" in Georgia annually (Fowler 2004). To put this figure in perspective, according to Boyd's (2001) calculations, this is equivalent to the waste load of a city of about 8 million people. Such a volume of "litter" far exceeds the quantity of fertilizer Georgia soil is capable of assimilating.² The excess runoff results in serious water pollution from nitrogen, phosphorous and an assortment of fecal pathogens.³ Additionally, recent work by Sarah Hemmings (2005) documents the persistence of endocrine-disrupting hormones from poultry litter in contaminated water.

Poultry's Transformation

The explosive growth during the 20th century of the U.S. poultry industry in general, and that of North Georgia in particular, was far from the simple expansion in size of an extant industry. To an observer from the 1920s, today's poultry industry would be virtually unrecognizable. The humble domesticated chicken, once a relatively minor component of family-farm economies and agro-ecosystems, is now the central concern of some of the largest and most vertically and horizontally integrated corporations on Earth.

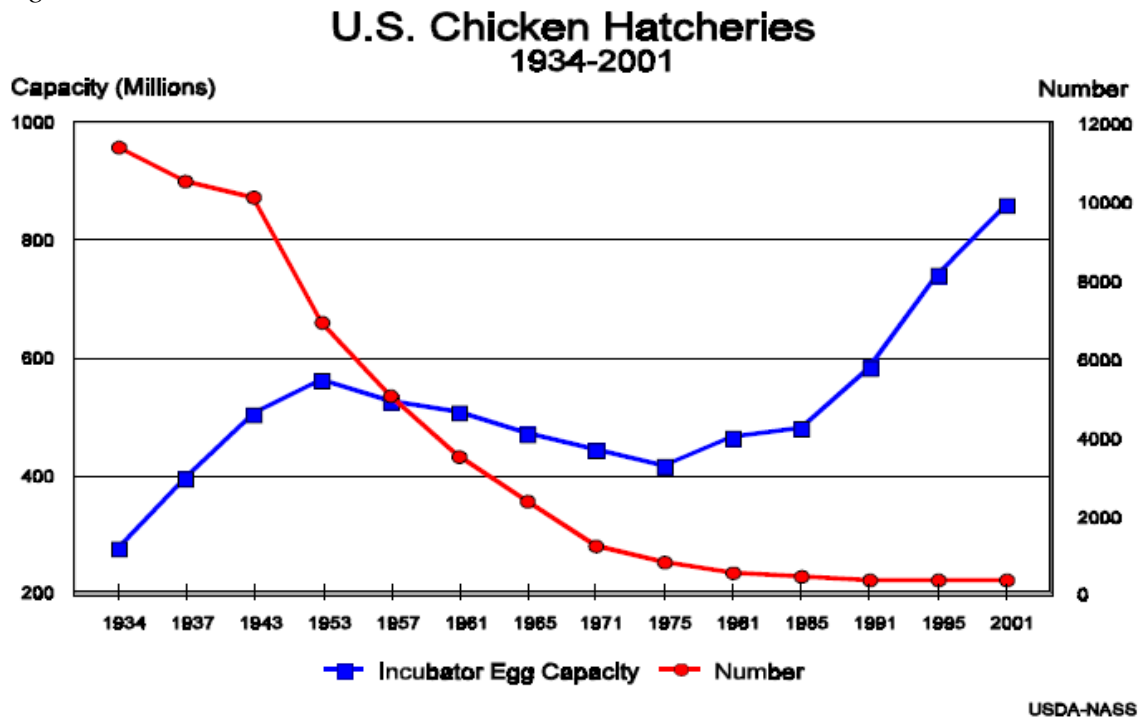
In 1934, 11,405 commercial hatcheries operated in the U.S., with a combined capacity to incubate 276 million eggs at one time, an average hatchery capacity of 24,224

² Shipping the poultry "litter" produced in the Southeastern U.S. to fertilizer deficit regions, such as the Midwestern "corn belt", while ecologically sensible, remains economically "irrational".

³ Southeastern whitewater kayakers, of whom I am one, know that it is a foolish (and very likely soon to be ill) paddler who inadvertently swallows water after a flood!

eggs. By 2001, the number of hatcheries had been reduced to 323, with the capacity to incubate 862 million eggs, an average of 2.7 million eggs (USDA 2002), (*See figure 2*). Ten companies account for almost two-thirds of U.S. broiler production (Watts 2000).⁴ Tyson alone controls nearly one-third of U.S. production (Lewontin 1998).

Figure 2



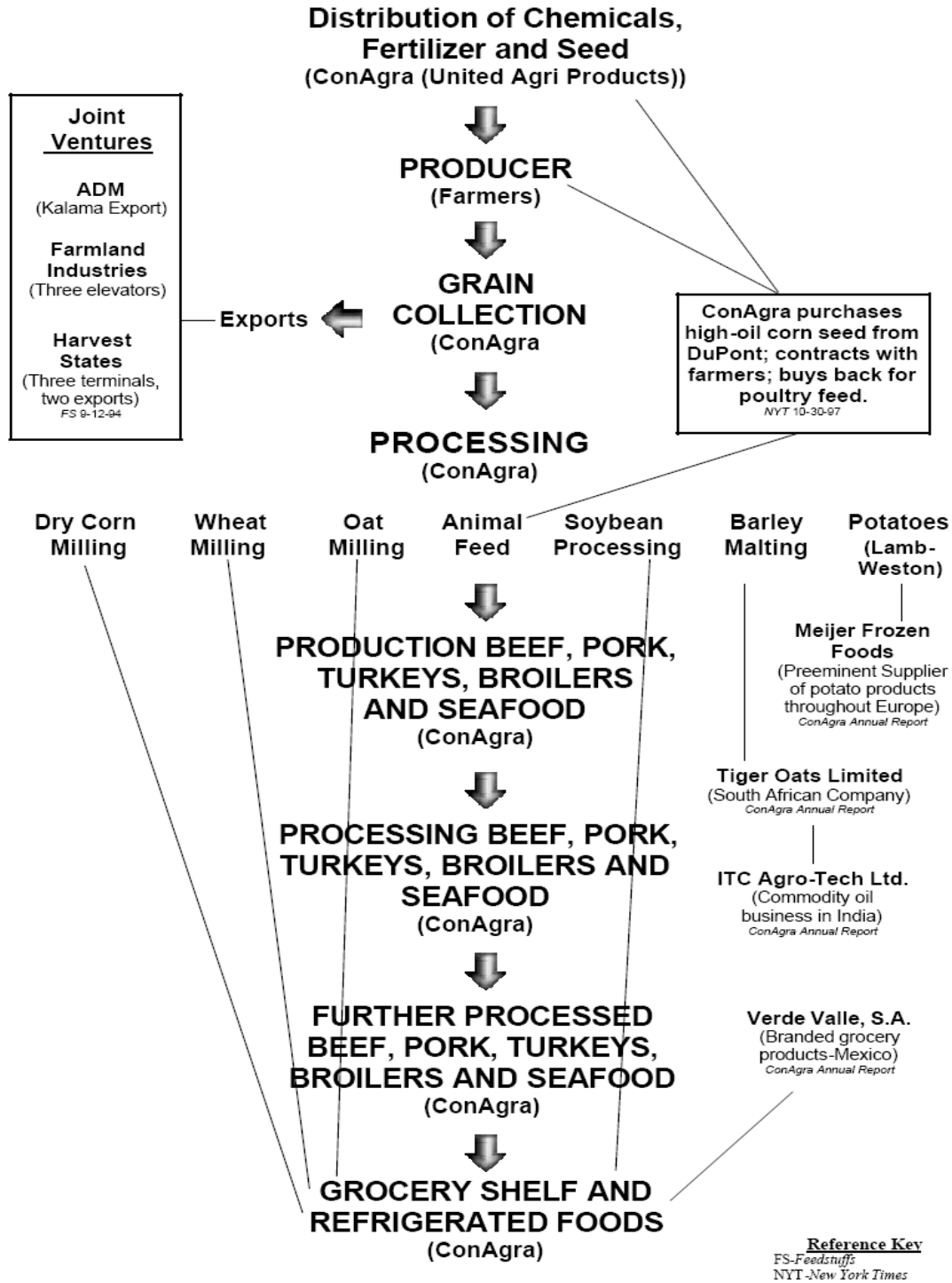
Source: USDA 2002

Such horizontal integration is matched by the industry's vertical integration, with the largest corporate players often owning everything from the agro-chemical inputs used to grow the poultry feed, to the genetic patents on the GMO seeds themselves, to the processing plants, to the consumer brands found on grocery store shelves (*See figure 3*).

⁴ As of 1997, the 10 largest broiler producers were, in order of size, Tyson Foods, Goldkist, Perdue Farms, Conagra, Pilgrim's Pride, Hudson Foods, Wayne Continental, Cagle's, Foster Farms, and Seaboard Farms (Perry 1999).

Figure 3

ConAgra Joint Ventures and Strategic Alliances



Source: Heffernan 1999

Within the lengthy and complex networks linking production, consumption, and, of course, the birds themselves⁵, exist many "nodes" worthy of theoretical and empirical exploration. The two sites at which humans and birds engage in the most significant physical interaction during the production process are the growing houses and the slaughter/processing plants. Poultry processing plants are exemplars of Taylorist (Taylor 1911) (dis)assembly-line production. The transformation of a live chicken into packaged parts ready for shipment to consumers is broken down into numerous simple steps, each of which is repeated *ad nauseam* by factory workers throughout their shifts. Plant workers face high injury rates (especially repetitive motion syndrome), but incentive pay is used to increase speed, which contributes to more injuries (Weinberg 2003). This division of labor is highly gendered. Men slaughter birds and operate heavy machinery; women perform fine cutting (personal observation 2002).

Even more pronounced than the gendered division of labor is the homogeneous ethnic composition of the laborers. While in 2000 just over 6% of Clarke county, Georgia residents were Hispanic, the workers in the plant I toured in 2002 were almost entirely so. Black representation was extremely small, and the only white workers I saw were managers or USDA inspectors. Far from an anomaly, the plant I toured reflects a general "latinization" of the processing plant labor force in the Southeastern U.S. which began during the 1980s as Mexico's economic troubles and the subsequent neoliberal "reforms" led to increasing legal and illegal immigration to the U.S. (Weinberg 2003). The economic and political marginalization of these recent immigrants leaves them little

⁵ The absence in the present work of explicit ethical consideration of the mistreatment and slaughter of billions of sentient beings for human pleasure and profit should not be read as a tacit approval of the moral status quo. Such considerations are simply beyond the scope of this work, and others (e.g. Singer 1990) have already developed compelling ethical critiques of the animal meat industry.

power to bargain for better wages or working conditions.⁶ A 1998 U.S. Government report, for example, cited nearly two-thirds of all poultry processing plants in violation of overtime payment laws (Watts 2000). The ruthlessly efficient processing factories, of course, would lack objects to "process" were it not for the work of the poultry farmers.

In contrast to bucolic imaginaries of small flocks of chickens wandering about family farms, eating insects and food scraps, today's birds spend almost their entire lives densely packed into 40 by 500 foot buildings. A typical broiler house costs \$120,000-\$140,000 to build and has a 25,000 bird capacity, providing each bird with less than one square foot of space. Five to six "flocks" are cycled through each house in a given year. The farmers themselves are no longer independent producers. Ninety nine percent are contracted with an integrator (Fowler 2004).

Under contract production, growers maintain ownership of land and buildings, but integrating firms strictly dictate all conditions of the production process and maintain ownership of all inputs (feed, medication etc.) and outputs (birds and eggs). "The contract farmer buys nothing, nor makes any decisions about the physical process of transformation," and "has no control over the labor process or over the alienated product" (Lewontin 1998: 79). Furthermore, the extreme level of corporate horizontal integration leaves growers heavily dependent upon the firm to which they are contracted. Paid per pound of live chicken, contractors have no long-term contract with integrators, but still owe the mortgage debt on the chicken houses (Weinberg 2003). As one politically astute Georgia poultry grower and organic vegetable farmer remarked, "Getting into the poultry business is the fastest way to serfdom I know of" (personal interview 2001). "The chicken farmer has ceased to be an independent artisan, buying materials, transforming

⁶ Georgia's status as a "right to work" state also contributes to labor's bargaining weakness.

them by his or her labor, and selling...in a market with many buyers," becoming instead "a proletarian without options" (Lewontin 1998: 78). Weinberg (2003) qualifies somewhat Lewontin's description by pointing out the long tradition of sharecropping in North Georgia. For many poultry growers, the shift to contract farming did not result in a significant loss of economic autonomy, as they had little autonomy to lose in the first place.

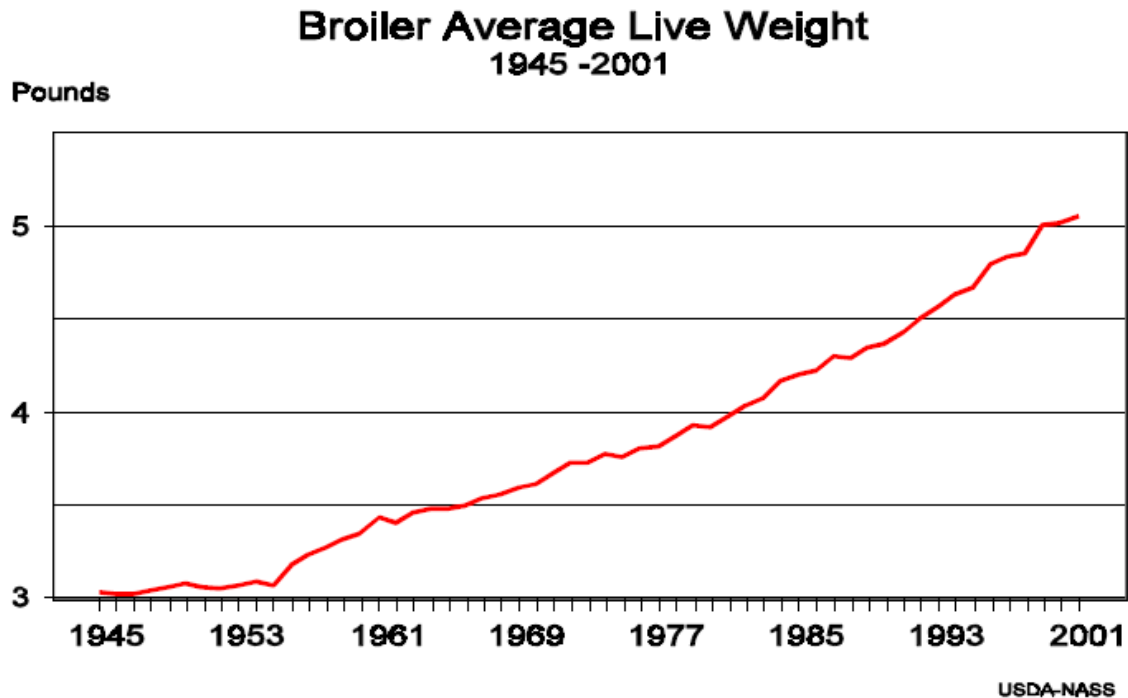
The Transformation of Poultry

"A chicken in every pot and a car in every garage...!"⁷

While the development of Georgia's poultry industry was certainly enabled by the pre-existing rural poverty and sharecropping tradition, it would have been impossible without technological revolutions in the very process of poultry production itself. "The prosaic chicken has been made over in such a way that it can only be thought of as bionic. In 1935 the average weight of the broiler was 2.8 lb, it took 112 days to reach market weight and had a feed conversion ratio (lb feed/lb broiler) of 4.4; fifty years later the figures are respectively 4.6 lb, 43 days and 1.9" (Watts 2000: 299) (*See Chart 4*). Boyd (2001: 638) documents many of the key technical developments through which this remarkable increase in productive efficiency was achieved. "Through technologies of confinement and continuous flow, nutrition and growth promotion, and breeding and genetic improvement, the barnyard chicken was made over into a highly efficient machine for converting feed grains into cheap animal-flesh protein."

⁷ Herbert Hoover's 1928 presidential campaign slogan reveals the degree to which chicken was perceived by many Americans as a "luxury" meat until the mid-twentieth century. Unfortunately for Hoover, of course, his promise did not come to fruition until long after the end of his term in office.

Figure 4



Source: USDA 2002

The technologies were many. The discovery of vitamin D in the 1920s, supplementation with which enables animals to survive in the absence of sunlight, allowed producers to permanently relocate poultry flocks indoors. Confirmation of the "multiple factor inheritance" hypothesis (that phenotype could be controlled by multiple genes located at different positions on a chromosome) and the subsequent development of quantitative genetics provided statistical rigor to poultry breeding, beginning in the 1940s. Rural electrification in the 1940s and 1950s facilitated a dramatically increased scale of production by reducing "man hours" needed per chicken. Artificial incubation technologies regulate production, while antibiotics are used both to ameliorate the continuous problems of disease related to intensive confinement, and as growth promoters. In fact, roughly half of the 50 million pounds of antibiotics produced

annually in the U.S. is mixed into animal feed at non-therapeutic levels for growth enhancement. Poultry producers were using 10.5 million pounds by the late 1990s, more than any other livestock industry (Boyd 2001).

Marxism, Functionalism, and Actor-Networks: Theorizing the Chicken as a Site of Capital Accumulation

Theorizing the development and structure of an industry as vast and multifaceted as that which puts Georgia chicken parts into the diets of humans around the world is no small task. Perhaps surprisingly, relatively few attempts at such theorizing have been made by geographers, or by social scientists in general. The critical scholarship which does exist on the poultry industry (e.g. Boyd 2001, Heffernan 1998, Lewontin 1998, McMichael 1998, Watts 2000), as well as that on other meat industries (e.g. Ufkes 1998), tends to theorize from a Marxist-Regulationist (e.g. Aglietta 1979) perspective. While the contemporary poultry processing factory provides a textbook example of the extraction of surplus value from labor by capital⁸, attesting to the continued relevance of Marx's (1976) work, the relationship between capital and the scientific community upon whose innovations capital depends is more problematic.

Boyd (2001: 633, 646) describes the creation of a "technological platform aimed at subordinating avian biology to the dictates of industrial production." "In effect, as the chicken was made over into a more efficient machine for converting corn and soybeans into animal flesh protein, the broiler industry became a vehicle for channeling the increased throughput of Midwestern corn and soybeans into higher-value food products

⁸ Indeed, one might be forgiven for wondering if he had not walked into an Upton Sinclair novel.

for retail supermarkets." Watts (2000: 299, 300; emphasis in original) labels the contemporary chicken a "cyborg", a "foundational example of the design of nature to meet the industrial labour process....The chicken is transformed into a *site of accumulation*; this is reflected in its curious physiognomy and anatomy ('all breast and no wings')." Similarly, Ufkes (1998: 241) argues "animal physiology is clearly an arena of industrial accumulation as growth processes and immunological responses are manipulated to produce new animal 'interior geographies' more befitting American dietary trends."

Such analyses, while certainly compelling, beg the question as to *how* the interests of capital articulate so neatly with those of scientific researchers. Were private industry itself responsible for such technological innovations this question would be unnecessary. However, as Boyd (2001: 635-636) explains:

As they did with other agricultural commodities, publicly supported scientists affiliated with the land-grant university complex performed much of the early basic research on the principles of poultry genetics, nutrition, and health, while private actors effectively assimilated this research and applied it for commercial gain.

But are the interests of corporate executives and shareholders necessarily the same as those of scientists? Though I am very sympathetic to the narratives already cited, the generality with which the relationships between capital and science are theorized leaves such analyses open to charges of functionalist reasoning.⁹

⁹ Due to the many disparate uses of the word "functionalism" in academic discourses, clarification is certainly called for. I use the word "functionalism" to refer to the all-too-common practice of conflating a thing's function with its reason for being. Such logic is ultimately ahistorical, that is, it is blind to genealogy. This kind of reasoning is hardly unique to the social sciences. Indeed, Gould and Lewontin's (1979) critique of the "adaptationist programme" in evolutionary biology profoundly influenced my conceptualization of functionalism.

Gibson-Graham's (1996) influential and scathing critique of Structural Marxist and Regulationist scholarship confronts this very weakness. While I take issue with many of their arguments and intellectual assumptions¹⁰, the charge of functionalist logic demands serious attention, if for no other reason than because such thinking can be found in the writings of leading Marxian geographers (e.g. Peet 1985). Gibson-Graham do not specifically address the agricultural political economy literature I have discussed, but one might easily imagine their criticism: *These narratives concerning the industrialization of agriculture and its integration into the circuits of capital have treated the role played by technology in enabling this transformation as an inevitable feature of capitalist expansion itself. The research scientists have no agency. Instead, they are merely the agents of capitalism. Differences, contestations, particularities, ambiguities, etc. have been "disappeared"*.

Can Marxist analyses be saved from such charges? I propose in the following chapters to demonstrate that they can. In so doing I will obey Gibson-Graham's admonition: "[capitalism's] hegemony must be theorized rather than presupposed" (1996: 18).¹¹ Accomplishing this task, however, will require that I draw upon another theoretical paradigm, Actor-Network Theory (ANT). Castree's eloquent (2002) call for the rapprochement of Marxist and Actor-Network approaches will serve as the starting point for this project, though the synthesis I develop will not be identical to his.¹²

¹⁰ These include their theorization of causality and (mis)use of "post"-structuralist semiotic critique. The first issue will be explored more fully in the following chapters. The second is beyond the scope of this work.

¹¹ To this I would add that in addition to being theorized, hegemony of any sort must be empirically investigated.

¹² While Castree focuses upon "green" Marxism and its conception of "nature", his engagement with ANT is nevertheless relevant to Marxist political economy in general.

Castree identifies four major shortcomings of Marxist political economy made visible by an ANT approach: use of binary logic (e.g. local/global, society/nature), explanatory asymmetry, a simplistic conception of actors and agency, and a "centered" understanding of power. As a counterbalance to these weaknesses, ANT has much to offer. With "network" as the guiding metaphor¹³, ANT encourages us to think "relationally" regarding agency, power, and explanation. "Within ANT, agency is conceived of not as some innate or static thing which an organism always possesses, but rather in a relational sense which sees agency emerging or as an effect generated and performed in configurations of different materials" (Philo and Wilbert 2000: 17). Indeed, ANT goes so far as to reject the assumption that the only significant actors in a network are human and that action/agency is necessarily associated "with intentionality and linguistic competence" (Castree 2002: 121). To emphasize this point, Latour, the scholar most strongly associated with ANT, coined the neologism, "actant", in order to avoid the ontologically loaded "actor". Thus, the agency of an "actant" results from its relationship with other "actants" within a network.

Intimately related to its theorizing of agency, ANT also conceives of power as an always contingent, temporary, dispersed, and shared phenomenon emerging from relationships *within* a network (Castree 2002). As Murdoch explains, "Tracing the topology of networks is...akin to tracing the topology of power for whoever succeeds in determining the connections which give rise to the spatialities and temporalities that

¹³ The recognition that a metaphor is integral to ANT need not imply a semiotic constructivist position. One might instead follow Ricoeur's (1977) thesis that, rather than occurring at the *expense* of language's referential function, metaphor, on the contrary, serves to *extend* that referential function. In the words of Anne Buttmer, "metaphor, however faded, can point beyond itself" (1982: 92).

compose our world" (1998: 370). Such network topologies are "relentlessly heterogeneous", because "ANT refuses to look for causes lying *outside* socionatural networks," and "refuses [the] presumption that different networks are driven by the same general processes or factors, be they 'capital' or 'class interests'" (Castree: 118, 119 ; emphasis in original). This assumption of "relentless heterogeneity" inspires an empirically-driven methodology (Brooks 2005). "It is only *after* each network has been carefully described that explanation can emerge" (Castree 2002: 119).

While finding much to praise, Castree also sees faults in ANT's more radical versions. The symmetrical understanding of "actants" can obscure ontological differences between the things comprising networks. (A chicken is not a human is not the H5N1 virus of avian influenza infamy, however profoundly interconnected they all might be!) In addition, the *a priori* assumption that each actor-network is unique leaves little room, if any, for generalizing theory. "Does inquiry into socionatural networks have to start afresh each and every time" (Castree 2002: 134)? ANT's empiricism can easily devolve into a kind of atheoretical positivism. If networks are inevitably "overdetermined", that is, if all actants are causally symmetrical, analysis can never move beyond description.¹⁴

With these caveats in mind, Castree proposes a "modest Marxism" according to which "the 'thing' we call capitalism is constituted by hundreds of thousands of commodity networks, which mix different people, machines, codes and artifacts in often unique ways, but (and this is the point) towards the same ends" (140). Thus, although

¹⁴ It is worth remembering that Waldo Tobler conceived the "First Law of Geography" in response to such a position (Tobler 2004). We might avoid the spatial fetishism inherent in his "law" while keeping its spirit by restating it as, "everything is related to every thing else, but *some* things are more related than others." Restated this way, of course, the "law" ceases to be exclusively *geographic*.

actor-networks are often heterogeneous, they may be driven by similar processes. And while power may be relational and dispersed, different actants nevertheless may vary in their ability to influence other actants. Castree's theoretical synthesis thus provides a promising paradigm for examining the relationships between agribusiness and agricultural scientists in a manner which avoids the Scylla of atheoretical description and Charybdis of functionalist Marxism.

CHAPTER TWO: Complex Systems and Actor Networks: The Issues of Scale and Causality

To Scale or Not to Scale?

If we are to integrate successfully the pursuit of theory and the performance of empirical research, a more sophisticated theory of scale will alert us against exploring a number of wasteful cul-de-sacs.

--Neil Smith 1992

For all its merits, Castree's account leaves unchallenged a significant tenet of ANT which, at the very least, is deeply problematic. This is ANT's treatment of scale, or more to the point, ANT's rejection of scale as either an ontological reality or an analytical device.¹⁵ Explanatory primacy lies with "connectivity", effectively "flattening" the world of actor-networks (ibid). "Actor-network theorists thus reject the view that social life is arranged into levels or tiers (some of which determine what goes on in the others); everything is kept at 'ground level'" (Murdoch 1997: 332). Murdoch reiterates the "grounded" nature of actor-networks in a later essay. "The action in actor-networks configures space....These actions, and the relations through which they are conducted, are 'grounded'; they never shift registers or scales but remain firmly within networks" (1998: 361). Latour makes a similar admonition:

If you set yourself the task of following practices, objects and instruments, you never again cross that abrupt threshold that should appear...between the 'micro' and the 'macro'....Social worlds remain flat at all points, without there being any folding that might permit a passage from the 'micro' to the 'macro' (1996: 240).

¹⁵ I also believe ANT's treatment of scale is incommensurable with much of Marx's thinking in *Capital Vol. I*. While this is not, of course, sufficient justification for rejecting the ANT approach, it is nevertheless significant to the project of integration.

The problems with these assertions are multiple. While I applaud the ostensible rejection of a local/global dichotomy, in practice this rejection amounts not to a transcendence of the dichotomy, "grabbing the bull by the horns", but to an implicit embrace of the dualism's first half. A world in which everything is "flat" is a world in which everything is local.¹⁶ Such a position uncritically privileges the scale of the human subject, ironically rendering the ANT approach cognitively anthropocentric, despite its ostensible rejection of anthropocentric notions of agency. Furthermore, as Engestrom argues, "abandoning levels"¹⁷ makes it difficult to account for...embeddedness" (1996: 262).

Confusing the situation, Murdoch endorses a statement by Law which seems to contradict his own position:

People are networks. We are all artful arrangements of bits and pieces. If we count as organisms at all this is because we are networks of skin, bones, enzymes, cells—a lot of bits and pieces that we don't have much direct control over and we don't know much about at all (Law 1994: 33; cited in Murdoch 1998: 367-368).

But if a person can both *be* a network and be an actant in a network, i.e. *be a part of a* network, does this not suggest the existence of multiple embedded scales? Though he did not explicitly theorize in poly-scalar terms, much of Marx's (1976) analysis of capitalist dynamics depends upon recognizing the significance of embeddedness. His discrimination, for example, between the interests of *individual* capitalists and those of

¹⁶ Castree himself retains a scalar dualism: "Capital is a complex of commodity-networks" which "are local *and* global" (2002: 140; emphasis in original).

¹⁷ Numerous social theorists (and ecologists) use the words "scale" and "level" interchangeably. As far as I can discern, the choice of one or the other is semantic. Sayre (2005) argues that the words do, in fact, have different meanings and should not, therefore, be used interchangeably. Unfortunately, I find his position too confusing to either accept or reject.

capitalists *in general* allowed him to observe systemic "contradictions" which would have been invisible to a "grounded" approach.

In recent years, the issue of scale in social theory has received much insightful and productive discussion by critical geographers (e.g. Brenner 2001; Marston 2000; Marston and Smith 2001; Purcell 2003; Sayre 2005; Smith 1992; Swyngedouw 1997). From this discussion, general agreement has emerged on several interrelated ideas regarding the ontological nature of scale:

1. Scales (at least those most obviously relevant to social theorists) are socially produced and contested.
2. Consequently, scales are not known *a priori*, but must instead be understood according to the processes producing them.
3. Because many causal processes operate across multiple scales, comprehending most social phenomena will demand a poly-scalar approach.

Neil Smith has argued, "There is nothing ontologically given about the traditional division between home and locality, urban and regional, national and global scales.... The differentiation of geographical scales establishes and is established through the geographical structure of social interactions" (1992: 73). Eric Swyngedouw further develops this line of reasoning:

Theoretical and political priority, therefore, never resides in a particular geographical scale, but rather in the process through which particular scales become (re)constituted....

The ontological priority for a process-based view...refuses to tackle global-local interplays in terms of a dialectic, an interaction or other mode of relating a priori defined things...a typically reified way of grappling with scale, assigning motive, force, and action to pre-given geographical configurations and their interaction rather than to the

struggles between individuals and social groups through whose actions scales and their *nested articulations* become produced as temporary standoffs in a perpetual transformative sociospatial power struggle.... The sociospatial structuring of the everyday does not in itself offer the local, the global, or any other scale as the preeminent site for analysis. The role, importance, and position of each geographical scale results from the dynamics of sociospatial transformations. *The role of particular geographical scales, their articulation and interpenetration, has to be theorized"* (1997: 141, 143; emphasis added).

Neil Brenner summarizes the consensus well:

Traditional Euclidian, Cartesian and Westphalian notions of geographical scale as a fixed, bounded, self-enclosed and pre-given container are currently being superseded – at least within the parameters of critical geographical theory and research – by a highly productive emphasis on process, evolution, dynamism and sociopolitical contestation.... Scale...cannot be construed adequately as a system of territorial containers defined by absolute geographic size (a ‘Russian dolls’ model of scales). Each geographical scale is constituted through its historically evolving positionality within a larger relational grid of vertically ‘stretched’ and horizontally ‘dispersed’ sociospatial processes, relations and interdependencies. Consequently, the very intelligibility of each scalar articulation of a social process hinges crucially upon its embeddedness within dense webs of relations to other scales and spaces (2001: 592, 606).

Such a nuanced *a posteriori* conception of scale need not prove incommensurable with ANT, as a recent statement by Sally Brooks (2005) suggests:

ANT analysis results in empirically driven accounts of distributional outcomes—how they come about, by the actions of which actors.... An important general principle, therefore, is, *not the rejection of categories and divisions of various kinds per se*, but the

avoidance of a priori, causal categories. Instead they are allowed to emerge from the empirical findings as effects (369; emphasis added).

Scale may or may not prove relevant to our understanding of specific actor-networks.

The point to remember is that we won't know until we look.

Complexity

To speak of 'non-linear' science is like calling zoology the study of 'non-elephant' animals.
--Stanislaw Ulam¹⁸

The eloquence of recent writings on scale by geographers notwithstanding, I can not help but concur with Nathan Sayre's (2005: 277) observation that discussion of scale within critical geography "has foundered on basic conceptual and methodological questions." Sayre finds in the discipline of ecology a plethora of sophisticated thinking about scale from which geographers might productively draw. Among the insights he gleans from ecology is the idea that cross-scalar processes may prove ontologically non-reductive:

What happens at a small scale cannot necessarily be extrapolated up, and vice versa, because results are nonlinear across scales.... This poses a fundamental challenge to reductionist science and its faith in quantitative methods.... Expressed in Hegelian language, thresholds are where quantitative change becomes qualitative change" (*ibid*: 280).

Though the phrase does not appear in his essay, Sayre is invoking the idea of "emergent properties", developed in general systems theory¹⁹ (e.g. Bertalanffy 1969).

¹⁸ quoted in Campbell et al. 1985: 374

This idea will prove critical in thinking about scale and, consequently, applying scalar thinking to understanding social processes. Before exploring this line of thought, however, a brief discussion of complex systems theory²⁰ will serve to clarify the broader intellectual context within which "emergent properties" become theoretically relevant.

Its mathematical sophistication and diversity of empirical application make a thorough and detailed treatment of complex systems theory beyond the scope of this chapter. Instead, I will provide a brief conceptual overview and then proceed to focus upon the issues most relevant to my critique of ANT's treatment of scale and causality. More of a meta-theory than a theory per se, "complex systems theory" provides a schema and vocabulary for analyzing processes that are both non-linear and non-chaotic. Though often referred to in the popular press as "chaos theory", complex systems theory is actually the study of "anti-chaos" (Lansing 2003). One may gain an intuitive sense of the difference between a linear system, a chaotic system, and a complex system through prototypical examples of each.

The parabolic trajectory of a cannon ball in flight may be predicted from initial conditions (e.g. mass of ball, angle of cannon, force of explosion etc.) using relatively simple mathematical equations (simple, that is, for those of us living after the development of Newtonian mechanics). More generally, linear systems are those in which "all variables are uniquely and precisely defined and... given values for all required parameters, the values of the variables at each instant in time are uniquely related to their

¹⁹ General Systems "Theory" is perhaps better thought of as a meta-theoretical perspective applicable to a diversity of disciplines. This semantic issue does not arise in the original German, in which "*theorie*" has a much broader meaning than does "theory" in English. Systems "thinking" might be a more apropos term.

²⁰ As systems theory has progressed over the past several decades (aided in no small part by the exponential increases in computational power, which have enabled the creation of increasingly sophisticated computer simulations of systems' behavior) the terms "complex systems theory" and "complexity theory" have superseded the original "general systems theory".

values at an immediately previous instant. A rule connects successive values of any of the variables" (Saperstein 1995: 549). Brownian motion, the random movement of particles in a gaseous state, exemplifies a chaotic system. Predicting the movement of any given particle proves impossible and no discernible patterns of organization emerge. Perhaps the most obvious example of complexity is organic life itself.

While not chaotic in nature, complex systems nevertheless behave in a nonlinear fashion:

We cannot obtain the future values implied by the theory just as a result of a compact, well-defined manipulation of present values. The calculation requires the actual computational stepping through of all intermediate values of the system variables between "now" and "then". Complexity theories thus depend on the complete "path" taken by the system between its beginning and end points. As such, they are sensitive to all perturbations that may lead to large, incalculable changes in the output....

The above paradigm is easily demonstrated in current ideas of biological growth. Instead of the whole future evolution of the entire organism being contained in each single cell...each cell contains a complete set of rules as to how it should respond to each potential environment (internal as well as external). It will behave one way if it finds itself surrounded by liver cells, a different way if surrounded by bone cells, and so on. Which specific environment it finds itself in depends on the 'path' it has taken since the 'beginning.' At each stage along the path there will be random small disturbances as well as deterministic major rules. The sensitivity at any point, which will vary from point to point, will determine whether and which bifurcations occur. In this way biological organisms grow with the similarities and differences commonly observed (Saperstein 1995: 550).

The nonlinearity of complex systems facilitates the transmission of information in a manner impossible in either linear or chaotic systems. This capacity, in turn, enables such systems to behave adaptively:

For food webs in rainforests to sustain biodiversity, innumerable specific flows of nutrients...must persist in the absence of any form of centralized control. Similarly, an

immune system also lacks centralized control and cannot settle into a permanent, fixed structure; instead it must be able to adapt to unknown invaders. Yet despite its protean nature, a person's immune system is coherent enough to distinguish oneself from anyone else (Lansing 2003: 183).

Increasing awareness of the ubiquity of complex systems has inspired applications of complexity theory in such diverse fields as economics (e.g. Arthur 1999; Foley 2003; Rihani 2002; Simpson 2000), sociology (e.g. Smith and Stevens 1996), climatology (e.g. Rind 1999), neuroscience (e.g. Koch and Laurent 1999), biology (e.g. Weng, Bhalla and Iyengar 1999), physical geography (e.g. Werner 1999), chemistry (e.g. Whitesides and Ismagilov 1999), and ecology (e.g. Gunderson and Holling 2002; Zimmer 1999).

"Common to all studies on complexity," observes Brian Arthur (1999: 107) "are systems with multiple elements adapting or reacting to the patterns these elements create."

Among the characteristics of complex systems most relevant for rethinking the relationships between causality and scale is the emergence of systemic properties irreducible to the system's individual components. To this we will now turn.

Emergence

Then the venerable Nagasena addressed the King.

"Your Majesty, how did you come here--on foot, or in a vehicle?"

"In a chariot."

"Then tell me what is the chariot? Is the pole the chariot?"

"No, your Reverence."

"Or the axle, wheels, frame, reins, yoke, spokes, or goad?"

"None of these things is the chariot."

"Then all these separate parts taken together are the chariot?"

"No, your Reverence."

"Then is the chariot something other than the separate parts?"

"No, your Reverence."

"Then for all my asking, your Majesty, I can find no chariot? The chariot is a mere sound. What then is the chariot? Surely what your Majesty has said is false! There is no chariot!..."

--From *Milindapanha*²¹

²¹ Quoted in Embree (1988: 105). The Theravadan Buddhist text, *Milindapanha*, relates a dialogue between the monk Nagasena and the Greek king, Milinda, who ruled portions of Northwest India during

Complex non-linear interactions may coalesce via processes of feedback into relatively autonomous structures displaying characteristics irreducible to the mere agglomeration of their constituents. It is this characteristic of complex systems which endows scale with ontological, as opposed to purely epistemological, significance. "If we shift our attention from the causal forces at work on individual elements to the behavior of the system as a whole, global patterns of behavior may become apparent" (Lansing 2003: 185). As one's scale of observation (episteme) changes, provided the "objects" in question are complex systems, one is not merely seeing the linear aggregation of constituent components, but, rather, emergent properties with unique ontological qualities. A biological cell, for example, is not simply an agglomeration of its constituent molecules, but exists only when specific configurations and processes occur. To be sure, the cell "appears" to the observer at a particular scale resolution, but the cell itself "emerges" ontologically at this scale of organization as well. Mitochondria, a few ribosomes, and a nucleus etc. do not make a cell, any more than a random gathering of humans makes a business, a class, a state, or a family. The organizational structure of the

the 2nd century B.C.E. One might imagine a contemporary dialogue, more immediately related to economic geography, as follows:

Then the heretical Chapura addressed the CEO.

"Mr. Walton, what is this trans-national corporation that you founded?"

"Wal-Mart," replied the CEO.

"Then tell me, what is Wal-Mart? Are you Wal-Mart?"

"No, your Irreverence."

"Or the shareholders, or the board of directors, or the check-out clerks?"

"No your Irreverence, none of these is Wal-Mart."

"Then the children in the Chinese factories, or the objects they produce, or the retail stores themselves, or the customers who patronize them?"

"No, your Irreverence."

"Then all these separate parts taken together are Wal-Mart?"

"No, your Irreverence."

"Then is Wal-Mart something other than the separate parts?"

"No, your Irreverence."

"Then for all my asking, your Highness, I can find no Wal-Mart..."

constituents proves just as critical, in some instances even more so, than the nature of the constituents themselves.

Of course, one may trace the emergence of novel properties in both scalar directions. The organelles comprising the aforementioned cell are themselves examples of complex systems, in this case comprised primarily of amino acids. As scale increases, cells may combine to form tissues²², which in turn make up organs, which, as part of organ systems, constitute an organism. While the examples I have thus far employed to illustrate the phenomenon of emergence may strike the reader as quite intuitive, particularly if they have some background in biology, it is worth emphasizing that particular instances of ontological emergence cannot be assumed *a priori*, but must instead be theorized and ultimately validated empirically.

Human language, both written and spoken, provides another illustration of emergent properties. Letters, symbols devoid of semantic content, may be combined in numerous ways to form words, carriers of meaning. These words may then be combined according to syntactic rules to create a virtually infinite variety of meaningful sentences. The meaning of each word, however, while clearly conditioning a sentence's meaning, will nevertheless be reciprocally conditioned by the sentence of which it is a part. A word's meaning depends upon the very semantic context which it helps to create.

Complex systems theory provides social theorists with a framework for comprehending the multi-scalar processes at work in human behavior and organization, for "understanding how cooperation, coalitions and networks of interaction emerge from individual behaviors and feed back to influence those behaviors" (Levin 2003: 3; quoted

²² Heart tissues grown in the lab from stem cells illustrate this quite vividly by pulsing rhythmically in unison as if "beating".

in Lansing 2003: 193). Human economic behavior serves as a case in point. Unlike the reductionism of orthodox neoclassical theory, economics approached from a complex systems perspective may appreciate the often-counterintuitive causal dynamics relating systems to their components. "Complex systems paradoxically tend to exhibit features that are in many respects the opposite of the tendencies of their components. The resolute pursuit of profit by individual capitalists, for example, may lead to a falling average rate of profit in the system as a whole" (Foley 2003: 8). Emerging from such complex interactions will be both formal and informal social institutions which, though historically contingent, are nevertheless real. Economic class, for instance, may be understood not only as a theoretical construct, but as an emergent property of capitalist relations of production.

Lansing's work on Balinese water management systems underscores the fact that "seeing" many important systems of human organization will require relaxing preconceptions of the forms such organizations might take:

[An] important development is the revelation, foreshadowed by theoretical work on complex adaptive systems, that social systems can emerge from the bottom up as a result of feedback processes linking social actors to their environment. Such institutions might look very different from those that social scientists normally study; they might even be invisible.... In the Balinese case, global control of terrace ecology emerges as local actors strike a balance between two opposing constraints: water stress from inadequate irrigation flow and damage from rice pests such as rats and insects. (Lansing 2003: 198-199).

Among the more theoretically significant implications of complex systems theory is the existence of causal relations operating bi-directionally between different scales of organization. "[E]mergent properties are thought to be autonomous to some degree of

their smaller-scale composite processes and even to have the capability of influencing events at lower levels of the organic hierarchy" (Ulanowicz 1990: 42). Given the rhetorical baggage associated with the term "hierarchy", such as its historical association with patriarchy and its connotation of a system of rigidly ordered ranks in which higher ranks control lesser ranks (e.g. Gibson-Graham 1996), I prefer Gunderson and Holling's (2002) term "panarchy". Greek for "rule of all", the term "panarchy" underscores the notion that causal or explanatory priority cannot be assumed *a priori* for different panarchical levels of organization. In other words, one should not assume that one scale is necessarily more important than another.

Returning to economics for an illustration of panarchical systems, we may recognize that the behavior of capitalist firms will be constrained by the political-economic milieu in which they operate. "[T]he modern corporation is a collectively self-sustaining structure of roles and obligations that 'lives' in an economic world, exchanges signals and stuffs, and survives or dies in ways at least loosely analogous to those of *E. coli*....Both *E. coli* and IBM coevolve in their respective worlds" (Kauffman 1995: 300). In addition to the sheer rhetorical appeal of comparing modern corporations to a strain of fecal bacteria complicit in countless cases of deadly food poisoning, Kaufmann's description captures the panarchical nature of economic processes. A corporation is comprised of numerous human actors whose roles and behavior are conditioned by the company's structure and goals, which, in turn, are constrained by the economic system in which it participates.

From Scale to Causality: Revalorizing Aristotle

It seems quite fair at this point to consider more critically a number of terms that have been employed thus far to describe the cross-scalar relationships between different panarchical levels. "Constraining", "conditioning", "influencing" etc. imply some form of causality, yet may leave one to wonder just what sort of causality this might be. Such an inter-scalar causality seems quite different (at least to this author) from that which occurs, for example, when one billiard ball strikes another, or when a rocket is launched into space. As Ulanowicz argues compellingly, comprehending the differences between linear and complex systems requires the expansion of causal models beyond those employed so successfully in the scientific study of linear systems. Fortunately, Ulanowicz reminds us, we need not begin this project from scratch. Aristotle has already done much of the work for us.

In his *Physics*, Aristotle describes four types of causality which may be at play in any given event -- material, efficient, formal and final:

In the familiar example of the building of a house the material cause exists in the mortar, lumber and other supplies going into the structure. The laborers and craftsman constitute the efficient cause, while the blueprints, or *bauplan*, is cited as the formal cause. Finally, the need for housing on the part of eventual occupants is usually taken as the final cause of building the house (Ulanowicz 1990: 43).

Ulanowicz argues that the success of Newtonian physics and the consequent adoption of mechanism as a model for all of science have left us with "a symbiosis of reductionism and positivism" in which "mechanical causes are considered efficient in nature, and the notions of formal and final causalities have been left to atrophy" (Ulanowicz 1990: 43). Formal and final cause, however, provide means of understanding the cross-scalar relationships between levels of a panarchy.

Systemic structures--"loops" in Ulanowicz's cybernetic terminology--may emerge ontologically from the behaviors of their components which possess the ability to influence the behavior and constitution of those very same components. As such an "autocatalytic feedback loop" emerges, "what might have begun as a chance configuration of composite mechanisms now possesses attributes proper only to the whole structure" (Ulanowicz 1990: 43). Eventually, a situation may arise in which the "structure of the system endures beyond the replacement of all its constituents, and where the overall configuration has exerted an active influence upon what those eventual replacements could be" (Ulanowicz 1990: 45). The causal effects of such a system upon its constituents, then, may be understood as formal in nature.

Most readers, I suspect, will find this description of formal cause to be relatively intuitive and easy to comprehend. But what of final cause? Ulanowicz's rethinking of teleology in terms of the dynamic interplay between scales in a hierarchy (panarchy) proves the most ingenious aspect of his thesis:

When a feedback loop is apparent at the focal level of the hierarchy, one perceives it as a formal cause. When the autocatalytic loop is acting at a fine scale, it will appear to the observer, along with manifold other agents, in the guise of an efficient cause.

Conversely, when the focal system is but part of at least one larger cybernetic loop, that unseen autocatalytic behavior will impress itself on the object system via the boundary conditions. That is, its influence will be perceived at the focal level as *final* in nature (Ulanowicz 1990: 45; emphasis in original).

Teleological behavior is thus understood to emerge in a panarchy from the influence of one system (playing the role of formal cause) upon its components.

In this cross-scalar interplay of formal and final cause, agency, too, appears as a relational phenomenon. Deriving from the Latin *agere* (to do), agency should be explicitly distinguished from sentience. Instead, agency may more broadly be understood

as "acting as cause", as statements such as "The workers were the agents of change" illustrate. If the arguments presented above are correct, however, agency, too, must be understood as an inter-scalar phenomenon. We should expect our perception of agency, therefore, to be inextricably tied to the resolution at which we observe a panarchic system.

The immune system illustrates this point well. A variety of specialized cells exist to find and destroy or neutralize pathogens that have entered the body. Observed at the cellular scale, the behavior of macrophages, neutrophils, and eosinophils etc. appears quite purposeful. They "discriminate" between different pathogens and "seek out" those which they may "attack" and will even alter their "attack strategy" so as to most effectively neutralize the pathogen. Such behavior suggests agency, yet I suspect I am not alone in having misgivings about attributing agency to individual immune cells.

Changing the scale of observation will improve our understanding of the mechanisms involved in this behavior, but will not resolve the search for agency²³. At a more refined scale we may see the roles of molecular signals and markers. A coarser resolution allows us to see individual cellular behavior as but part of a highly organized and coherent total immune response. Still, the scale at which we are witnessing agency remains unclear. We might expand our scale once again to the level of the organism. For the sake of argument, let us assume that I am the organism in question.

Without the proper functioning of my immune system I could not exist. Yet I am not consciously aware of its actions. I certainly cannot control the billions of cells constantly at work. In all honesty, I am quite thankful that I am not responsible for directing my immune system, as I would hardly know the details of what it should do. It

²³ That is, if we seek to locate agency at only one scale.

seems then, that I, *qua* self-aware consciousness, am not the agent of my immune system. For that matter, this line of reasoning makes me increasingly uncertain as to what it might mean to refer to myself (again, in the Cartesian sense) as an agent at all.

I am momentarily comforted by my ability to control my fingers as they press the keys of this keyboard. After all, I can ride a bike, play guitar, or simply walk across the room whenever I choose. Certainly these reveal agency!?! Soon enough, however, doubts reappear. I do not control the cellular metabolism and regeneration through which my existence is maintained. Moreover, most of the energy (in the form of ATP) used for these processes is produced by trillions of mitochondria, cellular "organelles" descended from bacteria which formed symbiotic relations with our cellular ancestors and still possess their own DNA!

But surely, as Descartes so (in)famously asserted centuries ago, *cogito ergo sum*, I think, therefore I am. Is it not a unified consciousness, transparent to itself, who thinks these thoughts? Is this not some fundamental "I" asserting itself? Turning in the other scalar direction, however, reveals this too, to be illusory. After all, the language which I use and ideas with which I play precede me. Heidegger spent a career "deconstructing" the Cartesian ego. The Being of *Dasein* is *ek-static* (Heidegger 1993). Translated into less obscure language—human subjectivity is always outside of itself, in the world and in language. "Man" does not speak, "language speaks" (Heidegger 1975). For Levinas (1987), too, human subjectivity was always and already outside of itself in its encounter with "the Other". Foucault (1978) operationalized these ideas with historical specificity by demonstrating some of the ways in which the human sexual subject was discursively

constructed through psychiatric narratives. Indeed, it appears that in whichever scalar direction I look, "I" am suspended across a lattice of Being.²⁴

For the sake of brevity I will end the thought experiment here, though it is worthy of note that numerous similar deconstructive musings exist in both the cognitive science and Buddhist psychology literature. As Dennis Hofstadter (1981) creatively articulates in a fanciful yet insightful essay *Prelude; Ant Fugue*, the best answer to such a search for agency is "mu" (the sound an infant makes), which in the Zen tradition implies that the question needs to be "unasked" because its present formulation precludes the possibility of any satisfactory answer.

De-centering causality and agency in this fashion should dissolve the false-dichotomy, so persistent in social theory, of "structure versus agency". Despite the inevitable anthropocentric perspective permeating most of our lives, social scientists should avoid the facile temptation of treating humans as the a-toms²⁵ of social theory. Nor, as should be clear from my earlier critique of Regulationism, should we embrace an anti-humanist structuralism, whether economic or linguistic. De-centering causality and agency in this fashion should *not* be understood as acceptance of the overdetermination²⁶ thesis presented by Resnick and Wolff (1987) and Gibson-Graham (1996), challenging the validity of causal explanation altogether. Causality and agency should, instead, be

²⁴ One might even be tempted, with apologies to Milan Kundera, to label this existential condition "The *Unbearable* Lattice of Being".

²⁵ "A-tom" is Greek for "not-divisible".

²⁶ Resnick and Wolff (1987: 19) describe overdetermination as the idea that "any event occurs as the result -- the effect -- of *everything else* going on around that event and preceding that event". Consequently, the argument goes, those claiming that certain factors are more explanatorily significant than others are guilty of essentialism, or, as Gibson-Graham (1996: 45) prosaically asserts, "the process of existence implicates all exteriors, and by virtue of this implication undermines the hierarchy of importance that defines some attributes or causes as necessary or essential, and others as contingent or peripheral, to a particular locus of being...".

recognized as poly-scalar phenomena.²⁷ Many actor-networks, those with emergent properties causally affecting the embedded constituents, should be recognized as complex systems. Not all actor-networks, however, will necessarily give rise to emergent properties. Discerning which do and which do not will require empirical inquiry. For those which do, scalar relationships will be relevant concerns.

²⁷ Smith and Stevens (1996) demonstrate the explanatory potential of just such an expansive multi-scalar analysis. By integrating cognitive science, developmental psychology, and sociology, this fascinating work explores the causal linkages between neuro-chemical pathways, the formation of infant-parent bonds, and community-level processes of socialization, without arbitrarily privileging one organizational scale over another.

CHAPTER THREE: "Grounding" Theory: An Empirical Exploration of Poultry Science Research at the University of Georgia

Project Description

Making plans is often the occupation of an opulent and boastful mind, which thus obtains the reputation of a creative genius by demanding what it cannot itself supply, by censuring what it cannot improve, and by proposing what it knows not where to find.
--Immanuel Kant²⁸

In an effort to overcome the functionalist tendencies of Marxist-Regulationist scholarship on agro-food systems, I have argued for a modified version of Noel Castree's (2002) synthesis of Marxism and Actor-Network-Theory. In contrast to Castree, the version of ANT I have proposed recognizes the ontological significance of scale and inter-scalar causal relationships. This enables me to theorize the community of university-based agricultural scientists and the community of agribusiness executives as overlapping, causally interacting actor-networks. In the spirit of keeping theory "grounded", I designed a small empirical study examining the relationships between the University of Georgia's Department of Poultry Science faculty researchers and the poultry corporations. This department is an ideal choice, both because it is part of a publicly-funded university and because it lies at the geographic epicenter of the global poultry industrial complex. If, as I have argued, the *observation that* academic poultry research often facilitates the acquisition of exchange-value by business interests can not also serve as the *explanation how* this occurs, the mechanisms through which the academic practices and discourses of university-based researchers are "translated"²⁹ by agribusiness into means of maximizing exchange value must be empirically explored.

²⁸ *Prolegomena to Any Future Metaphysics*, pg. 10

²⁹ "Translation refers to the processes of negotiation, representation and displacement which establish relations between actors, entities and places" (Murdoch 1998: 362).

Having critiqued the descriptions of the relationships between agricultural researchers and industry offered by Boyd (2001), Heffernan (1998), Lewontin (1998), McMichael (1998), Ufkes (1998), and Watts (2000), it seems only fair that I should venture into this descriptive territory myself.

Given the system of academic promotion in the U.S. university system, often affectionately referred to as "publish or perish", the acquisition of research funding by faculty (and aspiring faculty) is critical to career advancement. I hypothesized that much of the money available to researchers in the field of poultry science comes from sources with interests other than "the general pursuit of scientific knowledge". Specifically, I expected such interests to be financial.³⁰ Consequently, poultry research with certain aims (e.g., increasing the economic efficiency of production) will prove far more likely to receive funding than others (e.g., minimizing the suffering of the chickens or mitigating ecological externalities associated with production and processing that are not specifically prohibited by law). I further expected that many, if not all, of the poultry researchers would perceive the existence of these *de facto* economic constraints to their research agendas.

³⁰ By focusing upon economic forces I do not intend to imply any sort of economic determinism, whether the "cultural materialism" of anthropologist Marvin Harris (1979) or the "base-structure-superstructure" model proffered in some of Marx's own writings: "In the social production of their existence, men inevitably enter into definite relations, which are independent of their will, namely relations of production appropriate to a given stage in the development of their material forces of production. The totality of these relations of production constitutes the economic structure of society, the real foundation, on which arises a legal and political superstructure and to which correspond definite forms of social consciousness. The mode of production of material life conditions the general process of social, political and intellectual life. It is not the consciousness of men that determines their existence, but their social existence that determines their consciousness" (1904:11). On the contrary, my research points to the inadequacy of a purely economic analysis.

I anticipated that three variables would prove particularly relevant to understanding the relationship between funding and research:

1) The distribution of available funding along a public versus private continuum.

If most research funding comes from private sources, it would corroborate my hypothesis in a rather straightforward fashion. On the other hand, because I expect that public sources, such as the NSF or USDA, are likely to fund research that is not aligned with the interests of industry, if much of the available funding does come from public sources, establishing the validity of my hypothesis would be more complicated, and might demand rejecting or significantly revising the hypothesis altogether.

2) The concentration of funding sources. In other words, is the bulk of funding provided by one or a handful of sources, or do a large number of fiscally significant funding sources exist? In the first instance, the "power of the purse" would be understood to be concentrated in the hands of only a small number of actors. In the latter instance, economic power will be understood to be more dispersed, and in all probability to have less impact on shaping scientists' research objectives.

3) The academic prestige associated with different funding sources. Because I hypothesized that the need to acquire research funding in order to achieve academic promotion and prestige plays an important role in leaving university scientists vulnerable to the research demands of funders, it is important to understand which sources of funding (if any) are considered to carry the most professional prestige. I expected that certain funding sources, particularly federal research grants from the National Science Foundation (NSF) and U.S. Department of Agriculture (USDA), would be highly coveted

but limited in availability, whereas industry funding would carry less prestige but be more readily available.

Project Justification

By theorizing the community of agricultural scientists and the community of agribusiness executives as overlapping actor-networks, this empirical research serves as a case study for employing ANT to overcome the potential functionalism of Marxist-Regulationist approaches. "The conceptual tools of ANT", notes Brooks (2005: 370), are "useful for the microanalysis of the co-construction and extension of actor-networks, knowledge and policy." As Latour (2004) makes emphatically clear, the ANT approach to studying scientific communities differs significantly from that of the "sociology of knowledge" (e.g., Bloor 1999; Barnes 2004). Murdoch (1998: footnote 13) explains that "actor-network theorists sought to prevent natural scientific hegemony over social science being replaced by a social scientific hegemony over natural science. Thus, it is argued that social science should not seek to 'explain' natural science...." "In studying science and its relationship with nature, the co-constructionists have come to the view that the emphasis on social factors undermines the sociologist's ability to account for the power of modern science; that is, it fails to consider the material conditions that enable scientists to act effectively in the world" (Murdoch 2001: 117). In contrast, a "constructivist sociology of knowledge...appears as an almost insurmountable cognitive prison" (Schmidt 2001: 141). As such, the ANT "science studies" approach is consistent

with semiotic realism (e.g., Boyd 1988; Millikan 1984; Millikan 1993; Post 1996) and methodological realism (e.g., Sayer 1984).

Methodology

Interview data: I planned semi-structured interviews, designing interview questions (see appendix 4) to ascertain the nature of faculty members' ongoing and recently completed research, their motivations for designing these projects, their sources of funding, their perceptions of the nature of funding in their discipline, and what limitations, if any, they perceive to exist on the kinds of research for which funding is available. The seventeen full-time faculty members of the University of Georgia Department of Poultry Science were contacted via email to solicit their participation in the study.³¹ (See appendix 5 for a copy of the initial communication.) Of these, I was able to interview seven faculty members in person, and one additional faculty member answered the "interview" questions in writing.

Archival data: I obtained quantitative data, including dollar figures, funding sources, funding recipients, and research project descriptions, for the years 2001-2005, from the University of Georgia Office of the Vice President for Research (see appendix 3). These data are publicly available at <http://www.ovpr.uga.edu>.

³¹ Faculty members were contacted after the UGA Institutional Human Subjects Review Board had formally approved the research project, thereby granting me permission to interview the research "subjects".

A Note on Reflexivity and Positionality: I approached the faculty interviews with some trepidation. While my theoretical approach to the scientific practices in which the researchers are engaged can be described as "critical", a critical (in the interpersonal sense) approach to the interviews themselves would have proven counterproductive. Fortunately, my background in biology and ecology enabled me to intelligibly discuss their research in their own terms. Most interviewees were somewhat surprised by this, and I believe it facilitated the remainder of the interview by increasing their level of comfort discussing the "political economy" of their discipline with an "outsider" from the social sciences. My trepidation arose from the fact that the faculty were under no obligation to complete the interviews. I was particularly concerned (and perhaps a bit guilty of paranoia) that if an interviewee reacted with defensive hostility to my line of questioning, s/he might "warn" her colleagues against consenting to be interviewed, thereby fundamentally compromising my research design. In fact, nothing of this sort occurred, but the fear that it might prevented me from asking some particularly probing questions which could have improved the quality of the data obtained.

Data Results

Faculty: UGA Poultry Science faculty are officially appointed with either "research" or "extension" priorities. Most have some teaching duties as well. Of the eight interviewees, five hold "extension" appointments while three hold "research" appointments. The "mission statements" of each department branch clearly indicate the respective foci:

"Research conducted in the Department of Poultry Science has three primary functions:

1) Add to the base of scientific knowledge, 2) Provide opportunities for appropriate graduate degree training programs, and 3) Provide information that will be useful to the poultry industry in Georgia. These research programs encompass the following general areas: nutrition, physiology (growth and reproduction), processing technology, coccidiosis, genetics, microbiology (mycotoxins, spoilage bacteria), and programmed cell death (apoptosis)" (<http://www.poultry.uga.edu/research/introduction.htm>).

"The mission of the Extension Poultry Science faculty of the Department of Poultry Science is to provide relevant educational and service related programs for commercial poultry producers, allied industry representatives, county extension personnel, and small flock producers to enhance production and economic efficiencies while maintaining the state's competitive position in poultry production. The extension mission involves providing quality and timely educational programs, problem solving activities, and technology development and transfer through applied research and demonstration projects. The delivery of these activities is achieved by a combination of direct programming from Extension Poultry Scientists and delivery through County Agent personnel. In addition, the Extension Poultry Science faculty have responsibilities for providing County Agents and Vocational Agriculture Teachers support for poultry youth activities in Georgia" (<http://www.poultry.uga.edu/extension/index.htm>).

Working with private industry is clearly a priority for "extension" faculty, whereas industry needs are a tertiary goal of "research" faculty. The research projects of "extension" faculty tend to be "applied", whereas the research projects of "research" faculty tend to be "basic science". As it turns out, the funding sources for "research" and "extension" are the same. I would expect the emergent dynamic I describe to be more relevant for faculty with "research" appointments, as these appointments allow greater

latitude in terms of research focus. It is interesting to note, however, that the one faculty member with significant interest in "animal welfare" issues has an "extension" appointment.

The kinds of research in which the interviewed faculty engage vary. Three focus on issues of animal nutrition, which includes the digestibility and bioavailability of feed ingredients, maximizing meat and/or white meat yields, and determining uses for the by-products of biofuels. The last issue has gained particular salience for poultry producers recently, as the increasing demand for grains to produce automobile fuel has raised the price of feed-grains substantially. Three others focus on decreasing broiler morbidity through improved engineering of broiler houses and rearing practices. The most salient issue involves reducing ammonia levels through ventilation and treatment of poultry litter. Additional research interests include "cell-suicide", osteoporosis in laying hens, and the development of scoring methodology for animal welfare audits.

The rationales offered for their respective research foci vary as well. A clear division is apparent between "research" faculty and "extension" faculty. Four of five "extension" faculty mentioned "industry need" as the primary influencing factor. (The fifth described a long-standing interest in animal behavior.) In contrast, all three "research" faculty described their current work as carrying over from graduate and post-doctoral work. Other reasons included "serving humanity" and "wanting to do something important." Availability of funding was specified by only one researcher. This relative lack of salience is explained by the ready availability of industry funding for the kinds of research in which the interviewed faculty engage.

Funding Sources: The majority, 54.04%, of UGA Poultry Science Department extramural funding for the years 2001-2005, came from private industry. Of this, \$501,162 came from the U.S. Poultry and Egg Association (USPEA), an industry trade group, \$120,100 came from private companies in the form of direct gifts to researchers, and \$39,800 came from the Georgia Cotton and Peanut Commissions. \$101,489, or 8.30%, of extramural funding came from the U.S. federal government, specifically from the USDA. \$217,339, 17.77% of funding, came in the form of university-sponsored grants. The vast majority of this came from a single \$210,000 grant from the University of Delaware in 2001. Finally, \$243,369, 19.90% of total funding, was listed as "various income" by the University of Georgia Office of the Vice President for Research. I could not determine the source(s) of this funding.

Table 1: UGA Poultry Science Department Extramural Funding by Source 2001-2005

USPEA	\$ 501,162	40.97%
"Various Income"	\$ 243,369	19.90%
Other Universities	\$ 211,750	17.31%
"Gift"	\$ 120,100	9.82%
USDA	\$ 101,489	8.30%
GA Peanut/Cotton	\$ 39,800	3.25%
UofGRF	\$ 5,589	0.46%
Total	\$1,223,259	100.00%

*Table 2: UGA Poultry Science Department
Extramural Funding by Type 2001-2005*

Private Industry	\$661,062	54.04%
Federal Government	\$101,489	8.30%
University	\$217,339	17.77%
Unknown	\$243,369	19.90%

Prestige and Competitiveness: Grants from the federal government, such as the USDA, were viewed by interviewed faculty-members as being the most competitive to obtain and as carrying the most prestige. Direct funding from industry was viewed as least competitive and least prestigious. Grants from USPEA fell in the middle, both in terms of competitiveness and professional prestige.

Importance to Obtainment of Tenure/Promotion: All interviewees considered publication record in peer-reviewed journals to be the most important factor in obtaining professional advancement in academia. All interviewees viewed funding acquisition record as very important, even if less important than publication record. One faculty-member observed that a superb funding record can sometimes compensate for a mediocre publication record. Two interviewees observed that the importance attached to the acquisition of extramural funding for professional advancement has increased in recent decades. As one noted, "overall University budget cuts have led to a culture that values extramural funding." Tenure criteria vary according to the type of "appointment" each faculty member has, either "extension" or "research". However, the difference is one of degree, not of kind. "Extension" appointees are expected to obtain extramural funding,

but the consensus opinion is that extramural funding carries slightly less weight in promotion evaluations than it does for "research" faculty.

Elaboration of Data Results on Funding Sources

Because my research question centers on the relationships between faculty researchers and their funding sources, it is imperative to understand funders' objectives in providing research dollars. In this section, therefore, I devote considerable space to rendering these objectives visible. I give particular attention to the USPEA, because it contributes by far the greatest amount of funding, and to the USDA, both because its grants carry the greatest professional prestige, and because I expect it to be the most significant provider of funds to research projects not aligned with the interests of industry.

U.S. Poultry and Egg Association: One funding source dwarfs all others, both in terms of the number of grants awarded to the department faculty members, and in terms of sheer dollar amount: The U.S. Poultry and Egg Association (USPEA). All eight faculty members mentioned USPEA as a significant source of funding for poultry science research, both nationally and here at UGA. Six faculty members mentioned USPEA as providing them with funding for either ongoing or recent research.

Quantitative data corroborate the interview data. For the years 2001-2005, the UGA Office of the Vice President for Research (UGAOVPR) reported the total grant value for the Department of Poultry Science to be \$1,223,259. Of this, USPEA grants

accounted for \$501,162, or 40.97% of the total. This figure is more than double the second greatest source of grants, unspecified "Various Income", and is nearly five times the amount of grant funding obtained from the Federal government.

The USPEA, an industry-funded trade association headquartered in Tucker, Georgia, represents virtually all poultry companies in the United States. USPEA describes itself as "the world's largest and most active poultry organization of its kind. Our members include producers and processors of broilers, turkeys, ducks, eggs, and breeding stock, as well as allied companies" (www.poultryegg.org/Membership).

Funding research is among its primary objectives:

Since its birth in 1947, the U.S. Poultry & Egg Association has been a driving force in the poultry and egg industry. The mission centers around research, education, communications, and product promotion. Each year, USPOULTRY gives approximately \$1.2 million *to support research that benefits the poultry industry*. The association also sponsors the International Poultry Exposition and 13 educational programs that focus on specific industry management functions. USPOULTRY maintains a multi-pronged communications effort to keep people in the industry current on the issues that affect their livelihoods. The staff also communicates to the public the important role the industry plays in shaping the U.S. economy (<http://www.poultryegg.org/WhatWeDo/index.html>, emphasis added).

USPEA solicits research proposals designed "to resolve real industry problems" (http://www.poultryegg.org/Research/SearchEngine/research_VSearchForm.cfm#irn).

The specified research needs are divided into nineteen categories, each with multiple subcategories (see appendix 1 for a full list of subcategories with detailed descriptions).

The solicited research categories are, in order: genetics, nutrition, feed mill operations,

poultry housing, pullet management, breeder management (broiler/turkey), hatchery management, commercial egg production, broiler management, market turkey management, live haul, diseases, processing, food safety, further processing, packaging, rendering, waste management, and human nutrition.

USPEA grants are perceived by interviewed faculty as moderately competitive, which is consistent with the USPEA's estimate that 30% of grant proposals receive funding. These grants are perceived by faculty interviewees as carrying moderate prestige—more than that of direct industry funding, but less than that of government funding. Faculty interviewed expressed mixed feelings about USPEA. On the positive side, one interviewee stated that grants from USPEA were nice because it "doesn't haggle over every penny" (in contrast to government sources). Another faculty-member stated that USPEA grant committees are more "democratic" than government committees (ironically enough), better at recognizing good science, and more focused on "real world problems" than the comparable federal government funding agencies.

While the more scathing criticisms were reserved for federal government funding agencies, three interviewees did provide mild critiques of USPEA research priorities. Two argued that these priorities are too short-term. One stated that funds tend to go toward areas which industry fears have the greatest potential for government regulation, such as water and air quality. The corollary to this, the same interviewee stated, is that funding does not go towards research, the possible results of which industry fears might prompt increased government regulation or scrutiny. Another interviewee expressed a similar criticism, stating that USPEA is interested in "putting out fires", by which s/he meant avoiding publicity negative to industry, or funding research which might challenge

negative publicity. For example, s/he cited public concern over the cholesterol content of eggs as leading USPEA to fund research related to the impact of chicken feed formulas on egg cholesterol levels. Another interviewee argued that USPEA research priorities do not well represent the needs of poultry growers.

"Various Income": The second largest category of funding for the years 2001-2005, according to the UGAOVPR, is "various income". This accounted for \$243,369, or 19.90% of the \$1,223,259 total funding for the department. While I am inclined to infer that most, if not all, of this funding comes directly from private industry, because I am not able to confirm this inference, I will treat "various income" as coming from unknown source(s).

Grants from Other Universities: In 2001, a sizable grant of \$210,000 from the University of Delaware was awarded to a UGA Department of Poultry Science researcher. In 2002, a grant of \$1750 from The Georgia Institute of Technology was also awarded. Together, these two grants accounted for \$212,750, or 17.31% of the 2001-2005 grant totals. No interviewees mentioned grant awards from other universities in our discussions of research funding. I was not able to interview the recipient of the University of Delaware grant. I cautiously infer from my interviews that this large research grant from another university is anomalous.

"Gifts": The UGAOVPR reported \$120,100, 9.82% of Poultry Science Department external research funding as "gifts". Based upon my interviews with UGA Poultry

Science faculty, "gift" refers to direct funding from individual companies within the industry that is not mediated through an organization such as USPEA. Such direct funding is often given in order for the researcher to fulfill a specific need of the company, such as solving a technical problem, testing the efficacy of a new product (such as a new poultry feed formula), or to validate the company's "in-house" research. The latter occurs because results obtained by university scientists are viewed (justifiably, I would argue) as being more legitimate and trustworthy than the research results of company scientists with a potential conflict of interest. One UGA faculty member referred to such work as "feed and weigh" research. In other instances, such "gifts" from industry are provided to support the laboratory facilities and ongoing research of faculty, without restrictions upon how the money can be spent. Such unrestricted "gifts" will almost always go to faculty with an existing working relationship with the gifting company. One faculty-member observed that s/he is "on a first name basis" with people from the private companies with whom they work.

United States Department of Agriculture National Research Initiative (USDANRI):

The UGAOVPR reported \$101,489 worth of USDANRI grants for the years 2001-2005. This amounts to 8.3% of UGA Poultry Science researchers' grant awards for the same period. Total funding awarded by USDANRI for 2005 was more than \$161,000,000. However, while this annual funding figure for USDANRI dwarfs that of USPEA, the funding is distributed over *the entire U.S. agricultural research community* (see appendix 2 for a detailed breakdown of funding allocation by "program cluster" and subtopic for fiscal year 2001-2006). The general priorities of USDANRI are stated explicitly:

"The National Research Initiative Competitive Grants Program (NRI) at the Cooperative State Research, Education and Extension Service (CSREES) is charged with funding research, education, and extension activities to address key problems of national and regional importance in biological, environmental, physical, and social sciences relevant to agriculture, food, the environment, and communities on a peer-reviewed, competitive basis. To address these problems, NRI advances scientific knowledge in support of agriculture, forestry, and related topics. The program also supports the integration of research, education, and extension to generate, translate, and transfer new technology and knowledge into practical applications focused on solving problems of national importance.

The NRI was established in 1991 in response to recommendations outlined in Investing in Research: A Proposal to Strengthen the Agricultural, Food and Environmental System, a 1989 report by the National Research Council's (NRC) Board on Agriculture. This publication called for increased funding of high priority research, funded by USDA through a competitive peer-review process, directed at:

- Increasing the competitiveness of U.S. agriculture.
- Improving human health and well-being through an abundant, safe, and high-quality food supply.
- Sustaining the quality and productivity of the natural resources upon which agriculture depends.

Competition is open to scientists at all academic institutions, Federal research agencies, private and industrial organizations, and as individuals"

(http://www.csrees.usda.gov/funding/nri/nri_about.html).

Of most direct relevance to Poultry Science researchers, the program cluster "Animals" consists of five programs: animal reproduction, animal protection, animal genomics, animal genome reagent and tool development, and animal growth and nutrient utilization.

For fiscal year 2005, 89 grants, totaling \$24,303,989, were awarded under this program cluster. Program clusters were significantly reorganized for fiscal year 2006. "Animal genome reagent and tool development" is no longer a separate program, but is instead a component of the "animal genome" program. A biosecurity component has been added to the "animal protection" program. Otherwise the programs remain relatively unchanged. Research priorities for each program are as follows:

Animal Genome: The Animal Genome program provides science-based knowledge and technologies to generate new or improved high-quality products/processes and to promote the efficiency of agricultural production systems. This information will also enhance protection and safety of the Nation's agriculture and food supply through development and delivery of information/technologies to genetically improve animals of agricultural importance. The Animal Genome program has four program elements: Applied Animal Genomics, Tools and Resources, Bioinformatics, and Functional Genomics (<http://www.csrees.usda.gov/fo/fundview.cfm?fonum=1066>).

Animal Growth and Nutrient Utilization: Suboptimal nutrition and growth are limiting factors in animal productivity. Basic information regarding these processes in agriculturally important animals, including aquaculture species, is lacking. The primary objective of the program is to increase our understanding of the biological mechanisms underlying normal animal growth, development of skeletal muscle, lactation, and nutrient digestion and metabolism (<http://www.csrees.usda.gov/fo/fundview.cfm?fonum=1067>).

Animal Protection and Biosecurity: Maintaining and improving animal health to meet the food and fiber security needs of this Nation is an increasingly difficult challenge. The program develops and delivers science-based information and technologies to reduce the number and severity of program identified high priority agricultural disease outbreaks. The Animal Protection program has two program elements: Animal Disease and Animal Well-being (<http://www.csrees.usda.gov/fo/fundview.cfm?fonum=1069>).

Animal Reproduction: The objective of this program is to increase the knowledge base for reproductive biology of agriculturally important animals with the goal of reducing infertility and improving overall reproductive management in animal production systems. New knowledge is needed to improve fertility and facilitate implementation of integrated animal production systems that will contribute to sustainability of the animal production unit (<http://www.csrees.usda.gov/fo/fundview.cfm?fonum=1070>).

Additional programs of potential relevance to Poultry Science researchers, "air quality" and "watershed processes and water resources", are both under the "natural resources and environment" program cluster. These programs received \$5,293,741 and \$3,974,884 respectively, for fiscal year 2005. The research priorities for these programs are as follows:

Air Quality: Agriculture, forest, and range production practices have increasingly become subject to state and federal regulations that are meant to protect air resources. The long-term (10 year) goals of this program are: a) develop emission data for agriculture, forest, and range production practices that will lead to emission reduction targets, based on sound science, that will significantly improve air quality and protect human and environmental health; b) develop mitigation strategies that will increase adoption of best management practices to reduce agricultural emissions; c) and improve

understanding of odor, gases, and particulate matter (PM) measurement, production, flux, fate and transport that will lead to a better understanding of the environmental fate of agricultural atmospheric emissions.

<http://www.csrees.usda.gov/fo/fundview.cfm?fonum=1062>

Water and Watersheds: The goals of the Water and Watersheds program are to protect and enhance the natural resource base and environment by improving and maintaining healthy watershed habitat and water supply protection; enhance economic opportunities by reducing economic liability from water contamination; improve the quality of life in rural America through adequate clean water supplies; and protect food safety through clean irrigation and livestock drinking water supplies

<http://www.csrees.usda.gov/fo/fundview.cfm?fonum=1135>).

The relatively minor federal government contribution to department research funding, 8.3% of total extramural funding for 2001-2005, is consistent with my interview data. All interviewees were aware of USDA funding opportunities, but none mentioned it as a significant source of funding for any recent or ongoing research. USDA grants are perceived by all interviewees as extremely competitive and very prestigious. As one faculty-member observed, USDA provides "big money...if you're good".

USDA research funding priorities were viewed by interviewees as favoring "basic" science over "applied" science and long-term (5-10 years) projects over short-term projects. In general, attitudes voiced by interviewees regarding USDA research priorities and funding decisions were less positive than were their attitudes regarding USPEA. A general sense of mystery regarding the decision-making processes of USDANRI grant panels was ubiquitous. One interviewee stated that s/he doubted

"anything insidious", whereas another opined that it seemed the best way to obtain funding was to serve on a grant panel oneself, or, as another interviewee put, it helps to be in the "good ole boys" network. The most critical perspective came from one interviewee who labeled federal funding agencies "a plague on everybody," arguing that money is squandered by "chasing the latest scare". To illustrate the point s/he cited federal research funding of "food safety" concerns, such as salmonella, listeria, avian influenza ("bird flu") and "mad cow" disease, arguing that billions of dollars have been ill-spent on non-existent problems. No other interviewees expressed a comparably scathing degree of criticism. I cautiously infer that this is a minority perspective.

Georgia Cotton Commission and Georgia Peanut Commission: Both organizations are producer-funded, which is to say funded by private business. Total grants awarded to UGA Poultry Science faculty for the years 2001-2005 were \$39,800, 3.25% of total extramural funding, according to UGAOVPR. No interviewed faculty-members mentioned either organization as a significant funding source.

University of Georgia Research Foundation, Inc.: UGAOVPR reported \$5,589 worth of grant funding from the University of Georgia Research Foundation for the years 2001-2005, representing 0.46% of total extramural funding. No interviewed faculty mentioned this as a funding source.

Interpretation of Empirical Findings

The empirical data obtained through interviews and archival research seem to provide a straightforward corroboration of my hypothesis, that certain actors (private companies associated with the poultry industry) are able to employ indirect, but nevertheless real, financial pressure to influence the research projects pursued by university-based scientists towards goals perceived to be in their own financial interest. The results obtained for all three anticipated variables, *distribution*, *concentration*, and *prestige*, are consistent with this conclusion. Of the \$1,223,259 obtained in extramural funding for the years 2001-2005, the majority, 54.04%, came from private industry. Of this, most came in the form of research grants from the U.S. Poultry and Egg Association (USPEA), an industry trade group. In contrast, only 8.30% of extramural funding came from the U.S. federal government research grants, and 17.77% came in the form of research grants from UGA, Georgia Tech, and the University of Delaware.

The relatively small amount of funding from the USDA does not indicate an absence of interest on the part of interviewed faculty to obtain federal grants, as the acquisition of such grants is considered a prestigious accomplishment. Instead, the consensus among interviewees is that the relatively minor contribution of federal dollars to the department's total extramural funding results from the extreme competition across the entire agricultural sector for these funds. Obtaining federal research grants is fantastic, but good luck trying. While USPEA funding carries less professional prestige than federal funding, it is certainly not without prestige.

CHAPTER FOUR: Theoretical (and Practical) Conclusions

Productivity in relation to human wants and needs is very different from productivity in relation to the creation of surplus value...only when we fully comprehend the social meaning and social purpose will we be able to understand why certain technologies are chosen rather than others.

--David Harvey (1982: 102)

The poly-scalar complex systems framework developed in chapter two facilitates our theoretical understanding of the causal dynamics involved in constraining faculty research priorities. Following the work of Ulanowicz (1990), who applied a complex systems approach to ecosystem development, I will focus upon the impact of *selection* on a system's components. I expect that some readers will be uncomfortable with the language and reasoning I employ in the analysis to follow. I wish to stress, however, that my approach should not be conflated with sociobiology, nor do I intend to imply that the process of selection in a social system is identical to that of a biological system. Ecosystem development involves the selection of genetic patterns based upon the reproductive/survival fitness of the phenotypic expressions of these patterns, within specific bio-physical contexts. In contrast, selection in human social systems³² does not, in most instances, impact genes (obvious exceptions include eugenics and genocide). Instead, the selection that is most common in human social systems involves the selection of practices and narratives. "[T]he modern corporation," for example, "is a collectively self-sustaining structure of roles and obligations that 'lives' in an economic world, exchanges signals and stuffs, and survives or dies in ways at least loosely analogous to those of *E. coli*....Both *E. coli* and IBM coevolve in their respective worlds" (Kauffman

³² I specify *human* social systems because, while many animals form social systems, I do not intend my discussion of human social systems to be generalizable to other animals.

1995: 300). Just as Kauffman applies this theoretical perspective to understanding corporate behaviors, I am applying it to understanding certain behaviors of scientists.

Interviews confirmed that, as expected, one's record of acquiring extramural funding is an important criterion, second only to peer reviewed publication success, in the determination of professional promotion, including tenure, in the UGA Department of Poultry Science. Furthermore, because novel research greatly facilitates the potential for journal publication, success in obtaining grants will indirectly contribute to publication success, which is the most important promotion criterion. I have no reason to believe that the situation is different in other agricultural science departments across the U.S.

In the language of systems theory, aspiring faculty who are unable to obtain sufficient research funding will not be "selected" for continued participation in the system, that is, the department. Insofar as there exist more aspirants than tenured³³ faculty positions, competition for research funding will ensue. Given a greater demand for research funds than are available, those unable to successfully compete for funding will not "survive". Those who design research projects that appeal to the priorities of funders will be selected for continued participation within the system. Those who do not will be selected out of the system.

An important point I wish to emphasize is that this selection pressure is largely independent of the individual researcher's priorities themselves. By this I mean that aspiring faculty with research priorities that are inconsistent with those of funders will tend to be "selected out", unless they are willing and able to change their own priorities. The corollary to this is that those aspiring faculty whose research priorities are consistent with those of funders will be more likely to be "selected in". Those "survivors" who did

³³ Of course, the same criteria apply for obtaining a tenure-track professorship in the first place.

not have to alter their research priorities or those who did so unconsciously, might not even be aware that such a selection dynamic exists. This is because the selection dynamic is a characteristic of the system, and is not apparent if one were to take an atomistic approach, focusing exclusively on aspiring faculty as independent individuals. A shifting of scale is required.

This explication is analogous to Marx's (1976) analysis of overproduction in a capitalist economy. No individual capitalist intends to overproduce, nor does she even necessarily perceive that systemic overproduction is occurring, at least until prices fall. Overproduction results from the systemic competition exerted on all capitalists within an industry to maximize their appropriation of surplus value. A capitalist who recognizes the systemic overproduction and attempts to change her behavior, for example, by raising wages in order to create more effective demand, will be "selected out of existence". The atomist approach of orthodox neoclassical theory, by way of contrast, has a difficult time accounting for such "market failures", because it acknowledges only one scale of economic reality, that of individual human agents.

It is almost impossible, I would argue, to even discuss intelligibly the activities of poultry scientists without at least implicitly referencing multiple scales of organization. The genetic researcher seeking to improve growth rate or to increase the ratio of white to dark meat manipulates poultry genes, yet gene selection by the researcher is ultimately dependent upon the genes' phenotypic expression at the scale of the individual chicken. Furthermore, because the process does not (as of yet) involve techniques of directly manipulating genetic information at the molecular level, such as those used to produce

GMO and transgenic plants, breeding of individual chickens must still occur in order for selection of favored traits to occur.

As I have demonstrated, frequently the poultry scientist herself does not decide independently which phenotypic traits to develop. This decision can be traced to the source of funding enabling the scientist to engage in the research. Of course, businesses which provide research funding, whether directly or indirectly, do not exist in a vacuum either. They, too, are subject to the selective pressures of the economic markets in which they participate. One might object that I have erroneously attributed agency to "businesses", "corporations" etc., but that is precisely what I am doing, as justified by the discussion of causality in chapter two. Decisions as to which research to fund are, of course, made by people, not by institutions. These decision-makers may be husbands, wives, grandmothers, Catholics, Buddhists, Republicans, Libertarians, transgendered, of one ethnic group or another. However, *qua* employees of a business, these countless other identities fade into the background.³⁴ Their continued "existence" as a decision-maker within the company depends upon the continued existence of the company, which, in turn, requires that the company maintain profitability. Decision-makers who make decisions that are not conducive to the creation of profit will either be "selected out" of the company, or the company itself will be "selected out".

I am not arguing that the dynamic I have described is the *only* reason for the neat articulation between research and capital. This dynamic is worthy of focus both because it is not intuitively obvious and because it has not received attention in the geographic literature. In addition to the significance of hegemonic narratives, which I will discuss in

³⁴ I am in no way denying the existence of racism, sexism, ageism etc. in the workplace. These exist in spite of, not because of, the selection dynamic I am describing. Their persistence attests to the importance of non-economic dynamics at play in human social systems.

the section to follow, there remains the history of crony relations between politicians and capital, resulting in the subversion of public tax-dollars for the benefit of private interests. One faculty member pointed out in the course of our interview that ultimately the public is the largest financier of Poultry Science research, funding the material infrastructure (buildings, laboratories, etc.) and the faculty salaries. Private companies are thus able to "piggy back" on this indirect corporate welfare, paying only for the cost of the research itself. The political/financial relationship between capital and elected politicians, while not a focus of this work, is both a topic worthy of examination and one I expect would prove amenable to the theoretical framework I have developed.

Hegemonic Narratives and their Contestation: The Case of PETA and McDonald's

Despite the appearance of a rather straightforward empirical corroboration of my hypothesis concerning the poly-scalar economic dynamics conditioning the research foci of university-based poultry scientists, I will now qualify my analysis by examining the important role of narrative in shaping poultry science research agendas. The success of the "animal rights" group People for the Ethical Treatment of Animals (PETA) in prompting a focus by the poultry industry on issues of animal welfare during the last several years will illustrate the interconnection of the discursive and the material.³⁵

Throughout my interviews with UGA Poultry Science faculty, it became apparent that interviewees perceived their relationships with industry as largely positive. In other words, the fact that most research funding came from industry was not perceived as problematic, because the interests of the poultry industry were perceived in largely

³⁵ As a "critical realist", I consider this a valid ontological distinction.

positive terms. One interviewee did express concern that I would portray the department faculty as pawns of industry. S/he stated that the *Atlanta Journal Constitution*, a regional newspaper, had made such an accusation several years ago in an article critical of the Georgia poultry industry. S/he characterized the relationship between faculty researchers and industry as containing some tension, acknowledging that while industry clearly influences university research, faculty are able to leverage their close relationships with industry in order to influence the priorities of industry when they stray too far from the public good. S/he explained, for example, that UGA faculty have successfully steered the Georgia poultry industry towards greater environmental stewardship.

I do not doubt the veracity of this interviewee's characterization. However, even this interviewee's overall view of industry was primarily positive, stating, for example, that industry tends to be better at recognizing good science and more focused on solving "real world" problems than is the federal government. No interviewees spoke critically about the poultry industry's practices or objectives or appeared resentful of their dependence upon industry funding. While I have argued above that systemic processes of selection will make such a correspondence of priorities likely, such an economic analysis does not adequately capture the complete picture. Antonio Gramsci's (1991) notion of "hegemony" will facilitate a more nuanced explication.

Hegemony, as employed by Gramsci, refers to cultural narratives that have taken on the aura of "common sense" due to their ubiquity and believability³⁶. I understand Foucault's (1980) concept of "Power" to be very similar, though, of course, Foucault and Gramsci applied their concepts to different topics. A hegemonic narrative (or a discourse of Power) has the effect of influencing behavior without political, physical, or economic

³⁶ They possess "truthiness", to borrow comedian Steven Colbert's neologism.

force. In the course of my faculty interviews and perusal of industry literature, I identified two such narratives.

The first narrative I call the "Malthusian View of Human Hunger". According to this narrative, the global problem of human hunger is due to an inadequate supply of food. In order to eliminate hunger, certainly a worthy goal, we must increase the supply of food. This logic drove the scientific priorities of the Green Revolution from the 1950s through the 1980s (Dahlberg 1979, Griffin 1974, Lappe, Collins, Rosset, and Esparza 1998, Lipton and Longhurst 1989, Pearse 1980, Streeten 1987). Such Malthusian grammars remain ubiquitous in the public relations campaigns of agribusiness (Middendorf, Skladany, Ransom and Busch 1998) and its apologists (e.g., Avery 1995). The US Poultry and Egg Association's (2001) position paper on genetically modified organisms, for example, employs the same reasoning. "The U.S. Poultry and Egg Association believes that improved agricultural practices, including the use of GMO, will be the only way that producers of food will be able to meet the needs of an ever-increasing world population." A recent editorial that appears in the industry journal, *Meat and Poultry*, defending antibiotic use, shares this narrative trope. "Antibiotics prevent animal disease and improve meat, milk and egg production. These safe and proven tools remain absolutely necessary to meet the world's growing demand for affordable protein" (Alpharma 2007: 3).

One interviewed faculty-member, whose career began in and continues to involve international development in less affluent parts of the world, volunteered that s/he saw his/her work as "serving humanity", by facilitating increased food production. I suspect that such altruistic narratives, predicated upon Malthusian reasoning, are quite common

among researchers. That such a narrative trope should be employed by faculty discussing their professional objectives is not surprising, and I do not for a moment doubt the genuine sincerity of this researcher's humanistic motivations, nor do I doubt that many individuals employed directly by industry are similarly motivated by such goals³⁷. The primary problem with the "Malthusian View of Human Hunger" narrative is that it is empirically unfounded (FAO 2003). Critics of such logic, going back at least to Marx, have argued cogently that hunger is almost always a product of localized poverty rather than regional food supply (e.g. Dahlberg 1979, Griffin 1974, Lappe, Collins, Rosset, and Esparza 1998, Lipton and Longhurst 1989, Pearse 1980, Streeten 1987, World Bank 1986, Yapa 1993). A 1997 study by the American Association for the Advancement of Science (AAAS) found that 78% of all malnourished children under age five in the developing world live in countries with food surpluses (Lappe, Collins, Rosset and Esparza 1998). India, for example, exported almost two billion dollars worth of wheat, flour, and rice in 1995, yet a 1996 FAO survey found 61% of Indian children under five to be malnourished (Ibid.). The employment of this narrative by those associated with the contemporary meat industry is ironic as well, because the conversion of plant protein into animal protein is highly inefficient, though poultry is far more efficient than beef or pork. In other words, if the goal is to increase the food supply, feeding grains to animals is a counterproductive strategy.

The second narrative I call "Cartesian Anthropocentrism". Anthropocentrism, of course, was hardly unique to Descartes, but Descartes brought anthropocentrism to its most radical ethical conclusion. By arguing that (non-human) animals were mere

³⁷ *For-Profit Companies* cannot be understood to be driven by such ends, only employees. Whether or not the impact of a company's operations proves to be positive or negative to the public good, such effects are byproducts of the pursuit of profit.

automatons, machines incapable of real thought or sensation, he justified practices such as live vivisection, dissecting live animals in his laboratory (without anesthetic, which had yet to be invented) in order to study their organ systems "in action". This narrative is made visible in the poultry research milieu precisely because it is currently being successfully contested for the first time.

During the course of my interviews, three faculty-members stated that within approximately the last five years the poultry industry has become increasingly interested in funding research related to issues of animal welfare. At first, this seemed to contradict my hypothesis. I would not have been surprised to find faculty interested in researching strategies for minimizing animal suffering³⁸, but why would industry be interested in funding such research? A bit of subsequent investigation revealed an explanation that beautifully illustrates how contesting narratives may reverberate across interconnected actor-networks and ultimately translate into changing practices.

In 1997, the "animal rights" organization, People for the Ethical Treatment of Animals (PETA), began an aggressive public campaign designed to pressure the world's largest "fast-food" chain, McDonald's, into improving the welfare of the animals who would ultimately become its "Happy Meals", "McNuggets", and "Big Macs". Daniel Zwerdling (2002) describes the ultimately successful strategy:

PETA protesters were passing out brightly colored cardboard boxes to customers heading for McDonald's. If you glanced quickly, the boxes looked like a McDonald's Happy Meal promotion: big cheerful letters, a drawing of the grinning clown; but then you looked closely, it read "Unhappy meal" and Ronald McDonald was swinging an ax. When you

³⁸ In fact, one UGA faculty member whom I interviewed for this project does have this research interest, and has argued in journals and even at industry-sponsored conferences, that the well-being of poultry should not be ignored. S/he is a minority voice, however, considered controversial within the industry and research communities.

opened the box, you didn't find a hamburger, there were plastic animals painted with fake blood. The man who runs McDonald's denounced the protests as "tasteless and dishonest." But when the woman who runs PETA, Ingrid Newkirk, looks back on it today, she says McDonald's was on the ropes: "Just the very idea that we had taken their trademark Happy Meal and converted it into an Unhappy meal frightened them. Suddenly they didn't want children coming near the restaurant where they would see PETA protestors standing in the kiddy playgrounds with the Unhappy Meal in hand. That sent a chill up McDonald's spine." "It was pretty easy to settle on McDonald's," says Newkirk, "because they're the giant of the fast food industry and their name is instantly recognizable all over the world and the number of animals that they use to go into those burgers and those Egg McMuffins is just extraordinary. So we knew if we could get McDonald's to change—which is no easy task—the other fast food restaurants might fall like skittles."

The way PETA saw it, McDonald's was vulnerable. Consumers over in Europe were all fired up about animal welfare; they were getting their governments to pass laws that told food companies exactly how to raise their animals. Industry officials back in this country warned that the movement was heading here. So PETA figured that McDonald's executives had a choice: They could seem to drag their feet on animal welfare, PETA would keep harassing them, and eventually lawmakers might order industry to change. Or McDonald's could lead the campaign for animal welfare and they'd impress consumers as 'The company that cares,' and maybe they'd head off legislation. Around three years after PETA launched its protests, McDonald's became the first major food company to tell farmers, "You have to treat animals more humanely."

Specifically, McDonald's developed a set of welfare guidelines for layers (hens), and, effective January 1st, 2002, refused to purchase eggs from suppliers who failed to follow these guidelines (ibid). The issuance of these guidelines marked a major paradigm shift for poultry producers. Because poultry are exempt from the federal Animal Welfare Act and Humane Methods of Slaughter Act, poultry welfare had never before been a concern of industry. And because McDonald's is the largest single purchaser of eggs in the U.S., its decision reverberated throughout the industry.

McDonald's guidelines prohibited previously standard industry practices such as debeaking and forced molting, a practice of withholding food from hens for up to two weeks in order to temporarily stress their bodies into increased egg production (ibid). Interestingly, a position paper in support of forced molting, published in 1998, remains on the USPEA website (<http://www.poultryegg.org/PositionPapers/index.html>). This is but one example of industry's resistance to changing production practices because of animal welfare concerns. Recent statements by Richard Lobb, director of communications for the National Chicken Council, an industry trade association whose member companies account for 95% of all chicken sold in the U.S., reveal industry's antipathy towards "animal rights" organizations. Referring to a campaign by the Humane Society of the U.S. to replace electrical stunning prior to slaughter with controlled-atmospheric stunning, a practice rare in the U.S. but more common in Europe, Lobb argues:

The animal rights activists...[want to] make it as difficult and expensive as possible to produce and process animals for food. Their ultimate goal, of course, is to put all the chicken companies out of business, so we fail to see any benefit in trying to satisfy them (Aylward 2007: 66).

While the poultry industry might not be interested in trying to satisfy "animal rights" groups, McDonald's, with its extraordinary purchasing power, commands attention. Here we can witness how the sustained actions of one actor-network, the not-for-profit organization PETA, influenced the behavior of another actor-network, the for-profit corporation McDonald's. PETA succeeded in creating the perception among enough of McDonald's corporate management that *de facto* economic conditions had changed in the U.S. "fast-food" market, in this case that consumers were increasingly concerned with the (mis)treatment of food animals, as well as instilling a fear that *de jure* conditions might change if no preemptive actions were taken by the corporation to reassure U.S. legislators that no governmental regulation of poultry welfare was needed, such as existed in the E.U. Once those McDonald's executives with power to alter the behavior of the corporation's supply chains were convinced that changes would prove beneficial to their corporation's long-term success, changes were made.

The changing behavior of one actor-network (in this case, the particularly influential McDonald's corporation) then significantly altered the behavior of articulating actor networks, the egg-supplying companies contracted with McDonald's. "Ripple effects" occurred throughout the entire U.S. "fast-food" economy, as other large, for-profit actor networks, Wendy's and Burger King, responded to McDonald's changing behavior by implementing (and publicizing) similar animal-welfare regulations. Poultry companies, recognizing a changing economic landscape, one in which optimizing product price and quality were no longer the market's only relevant criteria, had to rethink their production practices if they were to avoid being "selected out" of the poultry industry.

This need ultimately translated into an increasing willingness to fund academic research on issues of poultry welfare.

This realignment of priorities by the poultry industry, however reluctantly, towards concern for establishing and maintaining a minimum threshold of physical and psychological well-being for the birds, beyond that necessary to maximizing profit, is a clear example of the power of narrative to realign the *de facto* rules according to which economic decisions are made. If the present trend continues, I expect that animal welfare will be a more significant research priority for the next generation of poultry scientists than it is for the current generation... and for the very same reasons that it has not been in the past. Everything is related to everything else, but some things are more related than others.

Closing Thoughts

The striking parallels between ANT and Complexity Theory, another of many historical examples of intellectual serendipity, inspired me to integrate the two. The most striking difference is their treatment of scale. ANT rejects scale as ontologically relevant, while Complexity Theory views reality as full of interconnecting and embedded scales. An additional (and related) problem with ANT involves the question of how to distinguish one network from another. While no system or network is ever *completely* independent from the rest of the world, Complexity Theory's conception of emergent properties which causally impact a system's constituents solves this problem by explaining the relative coherence of complex systems. I have argued that the Complexity

Theory view of scale as an ontological reality is correct, and operationalized this view through an empirical analysis of poultry science research. I do not want to throw out ANT altogether, however, because unlike applications of Complexity Theory to human social systems thus far, ANT has a robust appreciation for the critical importance of narrative, ideology, hegemony etc., aspects of human social existence that Complexity theorists have largely ignored.

While the empirical focus of this work has been limited to poultry science research, the theoretical implications extend to the entire social science endeavor. In order to understand human social systems we must recognize that agency is not the sovereign realm of human subjectivity. Instead, agency is dispersed, not only across networks, as ANT recognizes, but also across scales. My critique of the functionalist tendencies of Regulation Theory, therefore, is not intended as an outright rejection of that approach. I am not arguing that it is "wrong" in the same sense that Galileo argued that geocentric models of the solar system were wrong. My aim is to point out that it is empirically and theoretically incomplete, analogous, perhaps, to the relationship between classical and quantum physics.

In this sense I am not trying to "rescue" or "salvage" the agency of the researchers from the "structure" within which they operate. Such a formulation would simply recreate the very structure/agency dichotomy I have critiqued. I am well aware that some may protest that I have understated the agency (in the sense of a self-aware Cartesian ego) of the researchers. My response to such critique is that in this particular instance the "downward" causality exerted by the *systemic* competitive grant-seeking behavior of the network of researchers ("formal cause" in Aristotelian terms) is particularly powerful,

influencing its constituents, i.e. the researchers, by constraining the *telos* ("final cause" in Aristotelian terms) of their research. Having critiqued Regulationist explanations for the relationship between capital and science, the last thing I wish to do is devolve into a Cartesian fetishism of the ego. An explanation for the faculty members' research agendas based solely upon their individual agency proves incomplete. One cannot locate the research *telos* by looking exclusively at the individual researcher, any more than one can understand this *telos* by considering only the needs of capital.

In a recent essay in *Antipode*, James McCarthy (2005: 733) poses the question, "If scale is produced or constructed, then the questions immediately arise: who produces scale, how, and for what purposes?" The problem with this question is that it retains an implicit assumption of intentionality. Sometimes scale is produced intentionally. Sometimes, however, scale is produced by everyone and no one, without intention or even awareness. In the empirical context at issue here, the highly competitive grant-seeking behavior of researchers emerges from the significant undersupply of (non-industry) research funding and the importance of acquiring funding for promotion. This emergent dynamic enables capital to influence research objectives. The agency to determine the goals of the research projects in which they engage is constrained by the macroscopic context in which the individual faculty members operate, and which they co-create. And while private companies may be effectively exploiting this situation, they did not create the situation.

Recognizing the causal dynamics of the complex systems emerging from social interactions not only allows us to better understand the social world, but also provides insight into how to *transform* the social world. One can easily imagine, for example,

subtle changes that would dramatically curtail the power of capital to influence poultry science research. These might include minimizing the relevance of extramural funding as a promotion criteria or increasing the availability of public funding for research not driven by the needs of industry.³⁹ PETA's actions illustrate another example of altering behaviors through indirect means. The meat industry remains hostile to animal welfare organizations, but the campaigners at PETA recognized that they did not need to sway this industry directly in order to change its behavior.

James Glassman (2003: 266) has argued "structure is merely the agency of large collectivities of people....The only issues are whether, where and how some subset of a larger collectivity can gain enough support in its actions to substantially alter relatively long-standing features of the social relations that constitute 'the structure'". I hope that my theoretical discussion and empirical examples have convinced the reader that this is not, in fact, the case. Instead, structures emerge from the complex interactions of multiple actors and may reciprocally influence the behaviors of these actors. Structures are poly-scalar phenomena, not reducible merely to the summation of their constituent parts. I do not doubt that Glassman's idea of collective agency is indeed relevant to many important aspects of social existence. In fact, I would argue that it is apropos of the fast-food consumers PETA sought to influence and McDonald's sought to assuage. It is not sufficient, however, to comprehend many of the causal forces at play in human social existence. The poly-scalar approach I have proposed and illustrated will surely add to this endeavor.

³⁹ This may be easier said than done, but considering the significant public investment in infrastructure and faculty salaries that is currently appropriated by industry, the rate of return for the public of investing in the research itself would be enormous.

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APPENDIX ONE: Research Needs Identified by U.S. Poultry and Egg Association for Grant Applicants

Source:

http://www.poultryegg.org/Research/SearchEngine/research_VSearchForm.cfm#irn

Proposed research projects should be designed to provide information that has the potential to resolve real industry problems. The following list is organized by overall subject area. Items within each list are presented in priority order.

USPOULTRY realizes that new issues are always emerging and that scientists may see the importance of a potential problem that has not been recognized or cited as an industry research need. USPOULTRY invites proposals that address problems outside the industry lists but urges the submitter to provide ample background and justification to explain the need for the research.

Genetics:

1. Disease: Define the role of genetics in ascites. Devise ways to improve the immune response of poultry through genetics. Develop Marek's resistance in chickens through genetics.
2. Production: Define the role of genetics in egg shell quality. Use molecular genetics as a tool for improving desirable market traits in poultry. Provide genome mapping support.

Nutrition:

1. Diet Formulation: Define diets to allow complete withdrawals and good gut condition at processing. Develop diets to reduce fat pad. Devise formulations for "best yield."
2. Nutritive Requirements: Determine digestible amino acid requirements for broilers, breeders, and turkeys, especially lysine, methionine, and cystine. Requirements (energy and A.A.) for different strains for yield and efficiency. Establish nutritive needs with low selenium diets. Determine dietary requirement changes for up to 6.5 lb. broilers in controlled environments. Establish selenium requirements for poultry. Determine effects of "high" protein diets on egg production, hatchability, and livability. Define trace mineral and vitamin needs of breeder turkeys in late lays. Determine the influence of breeder nutrition on chick performance and effect of high dietary iron levels on breeder and broiler production.
3. Ingredients: Study impact of ingredients on environment (P, Se, Cu). Impact of biogenic amines in ingredients; (levels, type, synergism, better assays). Develop use for byproducts and determination of their ME values (DAF, sludge, deboning byproducts). Determination of interactive effects of different mycotoxins and intervention methods. Determine effect of feed ingredient quality on performance: how extremes in least-cost formulation alter FCR's and weights.
4. Miscellaneous: Determine influence of nutrition on dyschondroplasia. Define relationship of diet and ascites. Explore cellular mechanisms involved in nutrient absorption/biochemistry.

Feed Mill Operations:

1. Pelleting: Determine cost/benefit for pelleting/crumbling all pullet/breeder feed in improved health/performance. Establish the effects of post mix grinding on pellet quality and feed efficiency. Determine effects of ingredients and their combination on pelleting. Determine optimum ratio between pellets and mash in on-farm broiler diets.
2. Salmonella: Determine extent and source of Salmonella contamination in feed and if it relates to the flora of the birds. Determine parameters of conditioning and pelleting to kill Salmonella.
3. Equipment: Evaluation of expanders and seamless hammermills in feed manufacture.
4. Formulation: Compare effects of new crop grains/meals versus old crop on performance. Establish net energy guidelines for feed ingredients (primary grains vs. liquid fat).
5. Mycotoxins: Develop methods for detection of mycotoxins in ingredients before delivery to the feed mill.
6. Production: Devise methods to maximize quantity of feed produced per hour.

Poultry Housing:

1. Ventilation: Develop systems for black-out pullet houses. Devise techniques to reduce summer heat stress. Evaluate oxygen and ammonia sensors to monitor air quality. Determine optimal relative humidity.
2. House Type: Study curtain-sided versus totally enclosed houses on broiler performance. Determine optimal house for different climates, i.e., deep south, north, etc.
3. Broiler Breeders: Determine optimal slat height. Compare built-in electronic versus manual system of weighing. Conduct evaluation of cooling systems.
4. Miscellaneous: Develop energy efficient housing programs for pullets and broilers. Provide overview of different housing systems across the United States.

Pullet Management

1. Body Weight: Determine desired weights at different ages for optimum production and hatchability. Determine feeding programs to achieve desired weights. Evaluate frame size, conformity, and its relationship to weight in yield type broiler breeders. Determine optimal male weights throughout life for best hatch. Correlation of frame size with early egg size. Prescribe optimal body weights of males with mixed rearing. Determine if pullet uniformity is related to production.
2. Nutrition: Determine optimal feed formulation for high-yielding lines. Determine optimal feeding techniques, especially through six weeks of age. Define feed restriction effects on skeletal development and protein/fat deposition.
3. Lighting: Determine lighting, light restriction in relation to weight, uniformity, and maturity. Determine when light restriction should begin. Determine if debeaking is needed in black-out housing.
4. Density: Determine optimal density for black-out housing.
5. Develop new vaccination techniques to improve protection and lessen stress on the bird. Compare performance of separate and mixed rearing of males. Determine effect of house temperature on immune response.

Breeder Management (Broiler/Turkey):

1. Nutrition: Determine influences of male/female weight on production/ hatchability. Define role of diet in heat stress.
2. Lighting: Establish schedules for pullets/hens for maximum production/hatchability.
3. Nests: Maximize design/operation for optimal production/hatchability.
4. Vaccines: Compare effectiveness by injection site (breast vs. neck or leg). Develop vaccines that avoid need for mid-lay injection.
5. Broodiness: Develop strategies for control in turkey hens.
6. Egg Rooms: Develop methods for control of bacteria/molds.
7. Prevention of early male aggressiveness; establish ideal male-female ratios; provide means of prevention of floor/slat eggs; semen preservation/storage; determine ideal pullet age for moving to breeder house; determine role of feeder type; devise better egg hauling methods.

Hatchery Management:

1. Incubation: Determine optimal RH and temperatures for different chicken and turkey breeds. Investigate the benefits of manipulating carbon dioxide and oxygen levels in single-stage incubation. Determine impact of increased turning intervals during early incubation. Determine fresh air requirements during incubation to avoid oxygen deprivation. Determine effect of incubation time because of breeder flock age on mortality.
2. Sanitation/Disinfection: Determine optimal practices for effectiveness and employee safety. Explore alternatives to formaldehyde and methods for safe use of formaldehyde.
3. Operations: Explore opportunities for more automation. Establish the true incidence of repetitive motion disorders. Evaluate the in ovo injection system for vaccines and other products. Improve accuracy of candling for fertility. Develop improved chick delivery methods to lessen chick and employee stress.
4. Facilities: Devise methods to improve air management in older hatcheries using updated air control devices. Energy conservation systems development for hatcheries.
5. Miscellaneous: Determine relationship of egg size, chick size, and first-week mortality. Determine effect on hatchability of picking up and setting eggs twice weekly if eggs are held at 70 - 75 F. Determine the incidence and causes of losses in hatchery due to chick abnormalities.

Commercial Egg Production:

1. Dead Birds: Devise economical and environmentally acceptable means of disposal.
2. Spent Hens: Develop alternative methods for disposal of spent fowl other than slaughter/processing for human food.
3. Manure: Develop economical and environmentally acceptable management and disposal/utilization program.
4. Fly Control: Devise environmentally acceptable and residue-free systems of fly control.
5. Egg Size: Devise practices to prevent the production of excessively large eggs, especially in molted flocks.
6. Nutrition: Determine the role of diet on the extent of feather cover.
7. Lighting: Determine lighting needs as influenced by strain of hen.

Broiler Management:

1. Optimum Lighting: Determine influence of spectrum, intensity, length for different ages on performance and on development of ascites. Determine if the benefits from new lighting control systems justify increased compensation to growers to cover their costs for the improvement.
2. Temperature/Humidity: Determine optimum temperature and RH for broilers from day of age to processing.
3. Ventilation: Comparison of different types of systems on performance in different seasons/climates.
4. Brooding: Comparison of different methods using energy use, mortality, and growth rate as criteria.
5. Feeding: Comparison of full feed to meal time programs (grade, feed conversion, rate of gain). Determine quantities of starter, grower, finisher for optimal results.
6. Sanitation: Determine relationship of different practices to house performance.
7. Devise ways to control early body weight in open-sided houses. Develop methods to improve grower - integrator relations. Determine the influence of body weight and density on leg problems.

Market Turkey Management:

1. Early Poult Mortality: Determine causes and prevention.
2. Ventilation: Provide house design, compare natural versus power systems, provide convenient means for measurement of ventilation.
3. Darkling Beetles: Provide methods for control.
4. Breast Blisters/Buttons: Determine causes and prevention.
5. "Flip Over" Syndrome: Determine causes and prevention.
6. Leg Deformities In Toms: Provide methods for prevention.
7. Determine oxygen/temperature requirements of embryos of modern turkey breeds.
8. Develop bioengineered vaccines to immunize turkeys against various diseases at hatch.

Live Haul:

1. Catching/Loading: Devise mechanical catcher/loader and houses compatible with the equipment. Devise efficient way of handling larger chickens (5.5 - 6.8 lbs.) that will cause less mortality.
2. Cages: Develop improved cages that are lighter weight with more durable doors. Devise cage dumping systems that do not hang cage doors or damage cage bottoms.
3. Feed Withdrawal Time: Study times versus bird quality, yield, and shrink in hot weather and cold weather.
4. Cooling Sheds: Provide design for better, more efficient and uniform cooling of birds.
5. Miscellaneous: Evaluate effect of catcher pre-work warm-up exercises in reducing catching injuries. Impact of cleaning catching/hauling equipment on bacterial load on carcasses, especially Salmonella. Determine causes of DOAs. Develop methods to determine whether condemned turkey parts are associated with loading or processing.

Diseases:

1. Infectious Bronchitis: Develop rapid, precise methods for identification of isolates. Develop vaccines against variants.
2. Mareks Disease: Develop vaccines against new variants. Determine causes of "late breaks." Explore feasibility of genetic resistance.
3. Ascites: Determine if it is pathological or physiological. Define wholesomeness of affected carcasses. Devise prevention strategies.
4. Mycoplasma: Determine role of vertical transmission with recent isolates in broilers for MG and MS. Develop improved methods of diagnosis, prevention, treatment; controlling/eradicating in turkeys and chickens.
5. Infectious Bursal Disease: Develop methods for variant detection and develop vaccine with cross protection capabilities.
6. Fowl Cholera: Define extent of variation among isolates. Devise methods for determination of extent of post vaccinal immunity.
7. Turkey Poult Enteritis: Determine etiology, nutritional influences, epidemiology. Develop vaccines.
8. Layer Hepatitis Syndrome: Develop methods for prevention and control.
9. Avian Influenza: Develop methods for rapid detection and determination of pathogenicity. Develop cross protective vaccine.
10. Squamous Cell Carcinoma: Determine if neoplasm or inflammation. Define the etiology and provide prevention/control strategy.
11. Colibacillosis: Determine if primary or secondary pathogen. Define the role, if any, of poor ventilation.
12. Spiking Mortality, Stunting In Broilers: Determine etiology and devise methods of prevention and control.
13. Food Safety Microbes On Poultry: Devise methods for prevention/reduction of pathogenic bacteria colonizing poultry.
14. Alternative Dewormers For Poultry: Develop and evaluate new dewormers in chickens and turkeys.
15. Newcastle, Bordetella, Reoviruses, IP Syndrome, CAA, Scabby Hips: Acquire data on the prevention/control of these diseases.

Processing:

1. Repetitive Motion Disorders: Development of preventative measures/ programs.
2. Microbial Contamination: Develop methods for prevention of cross contamination, prevention of ingesta contamination leading to elimination of contamination on final product. Determine the actual feasibility of irradiation of poultry meat. Methods for the reduction of microbial levels in plant, optimal levels of chlorine (gas vs. liquid), development of automated inside-outside washer for reprocessing, verification of contamination levels on poultry meat. Evaluate effect of wrap paper treated with bacteriocins.
3. Killing/Stunning: Relate methods to blood removal and feather release. Explore feasibility of carbon dioxide stunning.
4. Bone Fragments: Development of automated, rapid, and accurate detection methods.
5. Equipment: Develop equipment for harvesting giblets with both yield and microbial load considered. Devise an efficient and stress-free way to cool birds prior to processing.

Develop deboning equipment to eliminate hand operations that are acceptable, based on yield and quality.

6. Stress: Determine effects of preslaughter stress on feather release, moisture gain/retention, and muscle tissue quality.

7. Miscellaneous: Determine the effect of electrical stimulation on muscle tissue quality, tenderness, and taste.

Food Safety:

1. Microbial Contamination: Preharvest - Determine effectiveness of "Nurmi" undefined flora for competitive exclusion in broilers administered in hatchery. Devise prevention strategies for *Campylobacter* infection of broilers. Define roll of contaminated feed in colonizing broilers with *Salmonella*. Define roll of *Salmonella* colonized breeders in producing colonized broilers at processing. Processing - Develop rapid, cost-effective, and specific methods of detecting microbial contamination. Study the feasibility of using chlorine on pickers to reduce contamination. Develop post-chill handling methods to reduce microbial contamination. Evaluate effectiveness of carcass dips/sprays in reducing microbial contamination. Evaluate the microbial benefits of HACCP implementation in processing plants.

2. Post Processing: Determine how to get consumer acceptance of irradiated food. Determine effectiveness of irradiation: microbiologically and organoleptically. Develop reliable and cost effective methods of bone fragment detection in deboned meat.

Further Processing:

1. Products: Devise methods to prevent the red bone splashing on fully cooked bone-in chicken while maintaining good yields. Develop improved pre-dust, batter, and breading to enhance adhesion to product. Develop consumer oriented packaging systems. Relate to yield the processing techniques such as length of age, meat temperature, and prior storage. Explore chilling alternatives as they relate.

2. Safety: Devise improved and rapid methods for the detection of metal fragments, bone, and other foreign materials in meat. Compare the different levels of bacterial contamination on salvage and fresh product after different handling techniques. Evaluate the effectiveness of chlorine as a sanitizer, comparing gas versus liquid systems.

3. Genetics: Develop a process that may be used for evaluating chicken lines for their marination absorption levels. Compare the different broiler lines for debone breast yield.

4. Miscellaneous: Develop ergonomic scissors, probably pneumatic, that can be used to trim small bones. Explore cellular/molecular biochemistry that may relate to meat toughness.

Packaging:

1. Materials: Develop packaging materials that are recyclable or compatible with waste management systems. Develop a temperature-abuse evident packaging film. Develop a more breathable film that would hinder ice crystal formation without reducing shelf-life. Develop stretch wrappers that function in cold and wet environments. Develop a waterproof box coating that will allow recycling of the box.

2. Packaging: Develop packaging for livers and gizzards to extend shelf-life. Develop

large containers (70 pound capacity) that are reusable and that can be ergonomically transported and stacked. Develop recyclable dry-pack bags. Develop a less expensive CVP bag with increased shelf-life capabilities, durability, and puncture resistance. Develop poly bags that are lighter, stronger, and recyclable.

3. Miscellaneous: Acquire data on proper box stacking. Research migratory chemicals moving from the packaging material to the product, evaluating for possible detrimental effects on the product and consumer.

Rendering:

1. Carcass Disposal By Rendering: Develop alternative methods for disposal of light spent fowl instead of processing and for disposal of mortality. Evaluate composting compared to rendering. Provide an economic study on consequences of slaughtering layers at different ages.
2. Products: Improve digestibility of feather meal. Define optimal feeding rates for feather meal in the different cattle diets. Explore possibility of edible products from rendered poultry materials.
3. Environmental Impact: Develop best practices for waste water and air quality compliance. Develop methods for odor control in the rendering process.
4. Process: Devise methods for processing lower grade items such as waste water by product, grow-out mortality, hatchery waste. Develop methods for handling and reducing skimmings. Devise methods to neutralize corrosive effects of waste water sludge in rendering plants.

Waste Management:

1. Litter: Develop improved, economical, and environmentally acceptable ways of disposal/use. Evaluate burning for brooding. Evaluate composting in houses, composting and retailing, materials designed to drive off the nitrogen from litter.
2. Dead Birds: Devise better methods of disposal such as composting, fermentation, and other options.
3. Processing Water: Develop new, less expensive methods to clean up water. Determine effects of liquid egg on municipal sewage treatment systems. Determine appropriate areas for water reuse. Devise method for substituting UV treatment for chemical water treatment. Devise ways to reduce BOD from processing plants and TSS in treatment plants. Reduce costs of biomonitoring for state agencies, methods for cleaning out anaerobic lagoons and disposing of waste. Develop methods to calculate water usage. Evaluate effectiveness of spray irrigation with treated waste water.
4. Other: Develop methods for disposal of hatchery waste, ways to reduce quantity of hatchery waste, and how to dispose of waxed boxes.

Human Nutrition:

1. Conduct an economic analysis of the value of eggs and egg products in the human diet relative to other foods.
2. Establish the relationship, if any, between egg consumption and serum cholesterol levels and type in healthy humans.

APPENDIX TWO: USDA National Research Initiative (NRI) Funding Allocation by Year

Source: <http://www.csrees.usda.gov/funding/nri/pdfs>

Table 2. National Research Initiative Funding Allocations¹, Fiscal Year 2006

	Awards	Total Dollars Awarded
Agroecosystems Program Cluster		
Soil Processes	18	3,669,471
Water and Watersheds	17	5,438,000
Air Quality	11	4,970,000
Managed Ecosystems	17	4,265,314
Biology of Weedy and Invasive Species in Agroecosystems	14	3,570,000
Rural Development	13	4,040,150
Agricultural Prosperity for Small and Medium-sized Farms	13	4,806,894
Total	103	30,759,829
Nutrition, Obesity, Food Safety and Quality Program Cluster		
Bioactive Food Components for Optimal Health	20	4,270,000
Human Nutrition and Obesity	16	10,970,000
Food Safety	16	4,296,200
Epidemiological Approaches for Food Safety	4	3,900,000
Nanoscale Science and Engineering for Agriculture & Food Systems	12	2,500,000
Food Safety Organized Research Unit (FS-ORU)	1	1,000,000
Total	69	26,936,200
Agricultural Genomics Program Cluster		
Microbial Genome Sequencing	8	5,000,000
Microbial Observatories	2	2,000,000
Animal Genome	23	8,682,645
Suborganismal Biology and Genomics of Arthropods & Nematodes	21	6,112,134
Plant Genome	18	7,089,000
Application of Plant Genomics Coordinate Agricultural Project (CAP)	2	2,396,000
Porcine Genome Sequencing Program	1	5,000,000
Total	75	36,279,779
Agricultural Biosecurity Program Cluster		
Animal Biosecurity Coordinated Agricultural Project (CAP)	4	3,292,538
Animal Protection	37	9,671,363
Plant Biosecurity	3	3,704,440
Organismal and Population Biology of Arthropods and Nematodes	21	5,930,390
Biology of Plant-Microbe Associations	19	5,235,290
Total	84	27,834,021
Agricultural Production and Value-Added Processing Program Cluster		
Animal Reproduction	18	4,022,768
Animal Growth and Nutrient Utilization	20	4,530,000
Agricultural Plants and Environmental Adaptation	11	3,070,001
Genetic Processes and Mechanisms of Agricultural Plants	17	4,170,000
Developmental Processes of Agricultural Plants	19	4,270,000
Agricultural Plant Biochemistry	15	4,170,000
Agricultural Markets and Trade	0	-
Improving Food Quality and Value	27	6,342,092
Biobased Products and Bioenergy Production Research	16	5,261,044
Total	143	35,835,905
Grand Total	474	157,645,734

¹The content of this table varies from tables provided in documents supporting the President's budget to Congress each year in that these data represent all awards made with Fiscal Year 2006 appropriated funds as of January 23, 2007, regardless of the year awards were made.

Table 2. National Research Initiative Funding Allocations¹, Fiscal Year 2005

	Awards	Total Dollars Awarded
Natural Resources and Environment		
Agricultural Plants and Environmental Adaptation	12	\$ 3,500,000
Watershed Processes and Water Resources	14	\$ 3,974,884
Soil Processes	21	\$ 4,600,000
Managed Ecosystems	11	\$ 4,710,000
Air Quality	12	\$ 5,293,741
Total:	70	\$ 22,078,625
Nutrition, Food Safety, and Health		
Bioactive Food Components for Optimal Health	13	\$ 3,833,750
Food Safety	20	\$ 5,010,533
Epidemiological Approaches for Food Safety	4	\$ 3,560,000
Human Nutrition and Obesity	14	\$ 10,900,000
Food Safety Coordinated Agricultural Project	1	\$ 1,000,000
Total:	52	\$ 24,304,283
Animals		
Animal Reproduction	21	\$ 4,342,541
Animal Protection	34	\$ 9,540,696
Animal Genomics	11	\$ 3,220,752
Animal Genome Reagent and Tool Development	4	\$ 2,700,000
Animal Growth and Nutrient Utilization	19	\$ 4,500,000
Total:	89	\$ 24,303,989
Biology and Management of Pests and Beneficial Organisms		
Arthropod and Nematode Gateways to Genomics	13	\$ 3,850,000
Integrative Biology of Arthropods and Nematodes	24	\$ 5,976,500
Biology of Plant-Microbe Associations	22	\$ 5,699,529
Biology of Weedy and Invasive Plants	15	\$ 4,062,605
Total:	74	\$ 19,588,634
Plants		
Plant Genome, Bioinformatics, and Genetic Resources	15	\$ 5,500,000
Genetic Processes and Mechanisms of Crop Plants	20	\$ 4,200,000
Developmental Processes of Crop Plants	18	\$ 4,197,000
Agricultural Plant Biochemistry	21	\$ 4,200,000
Application of Plant Genomics Coordinated Agricultural Project	5	\$ 2,000,000
Total:	79	\$ 20,097,000
Markets, Trade, and Rural Development		
Agricultural Markets and Trade	11	\$ 2,199,794
Rural Development	8	\$ 2,400,000
Enhancing the Prosperity of Small Farms and Rural Communities	7	\$ 2,500,000
Total:	26	\$ 7,099,794

Enhancing Value and Use of Agricultural and Forest Products		
Biobased Products and Bioenergy Production Research	16	\$ 5,573,234
Improving Food Quality and Value	28	\$ 5,988,679
Nanoscale Science and Engineering for Ag. and Food Systems	8	\$ 2,615,000
Total:	52	\$ 14,176,913
Emerging Issues		
Animal and Plant Biosecurity	9	\$ 6,716,332
Functional Genomics of Agriculturally Important Organisms	23	\$ 11,594,533
Total:	32	\$ 18,310,865
Inter-Agency Programs		
Microbial Genome Sequencing	8	\$ 5,577,000
Porcine Genome Sequencing	1	\$ 5,000,000
Climate Change Science Program	3	\$ 998,619
Total:	12	\$ 11,575,619
Grand Total:	486	\$161,535,722

Table 2. National Research Initiative Funding Allocations¹, FY 2004

Research Area	Number of Grants Awarded	Total Dollars Awarded
Natural Resources and Environment		
Plant and Environmental Adaptation	17	3,805,000
Watershed Processes and Water Resources	15	4,319,090
Soils and Soil Biology	18	4,663,142
Managed Ecosystems	13	3,708,982
Air Quality	11	5,000,000
Total: Natural Resources and Environment	74	21,496,214
Nutrition, Food Safety, and Health		
Bioactive Food Components for Optimal Health	22	4,418,000
Food Safety	23	4,678,990
Epidemiological Approaches to Food Safety	2	2,205,000
Human Nutrition and Obesity	13	8,239,727
Food Safety Organized Research Unit	2	2,295,000
Total: Nutrition, Food Safety, and Health	62	21,836,717
Animals		
Animal Reproduction	23	3,997,420
Animal Protection	40	11,123,668
Animal Genome	16	4,508,591
Animal Genome Reagent and Tool Development	2	1,614,481
Animal Growth and Nutrient Utilization	23	4,805,649
Total: Animals	104	26,049,809
Biology and Management of Pest Beneficial Organisms		
Arthropod and Nematode Gateways to Genomics	15	3,779,495
Integrative Biology of Arthropods and Nematodes	23	5,636,605
Biology of Plant-Microbe Associations	24	5,392,500
Biology of Weedy and Invasive Plants	14	3,564,000
Total: Biology and Management of Pest Beneficial Organisms	76	18,372,600
Plants		
Plant Genome, Bioinformatics and Genetic Resources	16	4,000,000
Genetic Processes and Mechanisms of Crop Plants	15	4,158,000
Developmental Processes of Crop Plants	22	4,153,000
Biochemistry of Plant and Plant Symbionts	30	4,405,000
Application of Plant Genomics Coordinated Agricultural Project	6	1,000,000
Total: Plants	89	17,716,000

Markets, Trade, and Rural Development		
Markets and Trade	5	1,921,000
Rural Development	5	1,996,800
Enhancing the Profitability and Vitality of Small Farms and Rural Communities	9	2,500,000
Total: Markets, Trade, and Rural Development	19	6,417,800
Enhancing Value and Use of Agricultural and Forest Products		
Biobased Products and Bioenergy Production Research	11	3,200,000
Improving Food Quality	32	5,971,143
Improved Utilization of Wood and Wood Fiber	12	2,184,006
Total: Enhancing Value and Use of Agricultural and Forest Products	55	11,355,149
Emerging Issues		
Animal and Plant Biosecurity	9	6,647,004
Functional Genomics of Agriculturally Important Organisms	16	7,511,668
Total: Emerging Issues	25	14,158,672
Inter-Agency Programs		
Metabolic Engineering Program	2	460,000
Microbial Genome Sequencing Project	7	5,000,000
Bovine Genome Sequencing Program	1	5,000,000
Geospatial Extension Specialist	6	480,769
Carbon Cycle Science	2	806,306
Total: Inter-agency Programs	20	12,064,075
Grand Total	524	149,467,036

Table 2. NRI Funding Allocations¹, FY 2003

Research Area/Program	Number of Grants Awarded	Total Dollars Awarded
<i>Natural Resources & Environment</i>		
Plant and Environmental Adaptation	21	3,343,932.00
Watershed Processes and Water Resources	22	4,410,615.00
Soils and Soil Biology	30	4,989,225.00
Managed Ecosystems	19	4,013,692.00
Air Quality	13	5,100,000.00
Total Natural Resources and Environment	105	21,857,464.00
<i>Nutrition, Food Safety, & Health</i>		
Improving Human Nutrition for Optimal Health	29	4,304,806.00
Food Safety	27	5,413,245.00
Epidemiological Approaches to Food Safety	6	5,484,233.00
Human Nutrition and Obesity	12	8,200,000.00
Total: Nutrition, Food Safety, & Health	74	23,402,284.00
<i>Animals</i>		
Animal Reproduction	20	3,817,548.00
Animal Protection	53	10,745,048.00
Animal Genome	16	3,842,546.00
Animal Genome Reagent & Tool Development	3	2,090,892.00
Animal Growth and Nutrient Utilization	30	4,659,738.00
Total: Animals	122	25,155,772.00
<i>Biology and Management of Pest Beneficial Organisms</i>		
Integrative Biology of Arthropods & Nematodes	36	5,560,180.00
Biology of Plant-Microbe Associations	30	5,463,081.00
Biologically Based Pest Management	17	3,067,356.00
Biology of Weedy and Invasive Plants	22	3,644,096.00
Total: Biology and Management of Pest Beneficial Organisms	105	17,734,713.00
<i>Plants</i>		
Plant Genome	22	4,603,082.00
Genetic Processes & Mechanisms of Crop Plants	26	4,382,932.00
Developmental Processes of Crop Plants	33	4,589,442.00
Biochemistry of Plant and Plant Symbionts	26	4,356,675.00
Application of Plant Genomics Coordinated Ag. Project (CAP)	1	1,000,000.00
Total: Plants	108	18,932,131.00

<i>Markets, Trade, & Rural Development</i>		
Markets and Trade	14	1,998,762.00
Rural Development	15	1,961,365.00
Total: Markets, Trade, & Rural Development	29	3,960,127.00
<i>Enhancing Value and Use of Agricultural and Forest Products</i>		
Biobased Products & Bioenergy Production Research	18	2,785,648.00
Improving Food Quality	37	6,389,298.00
Improved Utilization of Wood and Wood Fiber	18	1,954,019.00
Total: Enhancing Value and Use of Agricultural and Forest Products	73	11,128,965.00
<i>Inter-Agency Programs</i>		
Metabolic Engineering Program	2	300,000.00
U.S. Rice Genome Project	4	1,488,082.00
Microbial Genome Sequencing Project	11	5,328,000.00
Bovine Genome Sequencing Program	1	4,790,034.00
National Training Program for Agricultural Homeland Security	2	500,000.00
Functional Genomes of Agriculturally Important Organisms	10	8,095,351.00
Nanoscale Science and Engineering	5	915,000.00
Geospatial Extension Specialist	6	980,769.00
Carbon Cycle Science	2	1,339,099.00
Animal and Plant Biosecurity	8	7,600,000.00
Total: Inter-Agency Programs	51	31,336,335.00
Grand Total	667	153,507,791.00

Table 2. NRI Funding Allocations¹, FY 2002

Research Area/Program	Number of Grants Awarded	Total Dollars Awarded
<i>Natural Resources & Environment</i>		
Plant Responses to the Environment	29	\$3,300,000
Water Shed Processes and Water Resources	20	4,370,000
Soils and Soil Biology	23	4,774,000
Managed Ecosystems	14	3,685,357
Total: Natural Resources and Environment	86	\$16,129,357
<i>Nutrition, Food Safety, & Health</i>		
Improving Human Nutrition for Optimal Health	24	4,337,215
Food Safety	28	5,987,555
Epidemiological Approaches to Food Safety	7	5,545,000
Total: Nutrition, Food Safety, & Health	59	\$15,869,770
<i>Animals</i>		
Animal Reproduction	24	3,906,549
Animal Health and Well-Being	55	11,047,597
Animal Genome Basic Reagents and Tools	20	6,000,000
Animal Growth, Development, and Nutrient Utilization	26	4,419,594
Total: Animals	125	\$25,373,740
<i>Biology and Management of Pest Beneficial Organisms</i>		
Entomology and Nematology	34	5,725,000
Biology of Plant-Microbe Associations	33	6,080,000
Biologically Based Pest Management	17	3,140,000
Biology of Weedy and Invasive Plants	14	2,640,000

Total: Biology and Management of Pest Beneficial Organisms	98	\$17,585,000
<i>Plants</i>		
Plant Genome – Bioinformatics and Data Management	5	1,800,000
Plant Genetic Mechanisms	38	5,435,490
Plant Growth and Development	41	4,787,510
Agricultural Plant Biochemistry	41	4,735,000
Total: Plants	125	\$16,758,000
<i>Markets, Trade, & Rural Development</i>		
Markets and Trade	21	2,065,200
Rural Development	18	1,849,200
Totals: Markets, Trade & Rural Development	39	\$3,914,400
<i>Enhancing Value and Use of Agricultural and Forest Products</i>		
Food Characterization/Process/Product Research	27	4,000,000
Non-Food Characterization/Process/Product Research	17	3,000,680
Improved Utilization of Wood and Wood Fiber	13	1,700,000
Total: Enhancing Value and use of Agricultural & Forest Products	57	\$8,700,680
<i>Inter-Agency Programs</i>		
Metabolic Engineering Program	2	300,000
U.S. Rice Genome Project	2	1,018,000
Microbial Genome Sequencing Project	4	3,965,000
Total: Inter-Agency Programs	8	\$5,283,000
GRAND TOTAL	597	\$109,613,947

Table 2. NRI Funding Allocations¹, FY 2001

Research Area/Program	Number of Grants	Total Dollars Awarded ²	Research Area/Program	Number of Grants	Total Dollars Awarded ²
Natural Resources & Environment			Plants		
Plant Responses to the Environment	18	\$3,090,000	Plant Genetic Mechanisms ³	34	4,833,571
Watershed Processes and Water Resources	18	4,124,049	Plant Growth and Development ¹⁰	28	3,646,000
Soils and Soil Biology	23	4,380,600	Agricultural Plant Biochemistry ¹¹	34	3,914,847
Total: Natural Resources and Environment	59	\$11,594,649	Total: Plants	96	\$12,394,418
Nutrition, Food Safety, & Health			Markets, Trade, & Rural Development		
Improving Human Nutrition for Optimal Health	22	4,774,458	Markets and Trade ¹²	21	1,984,000
Food Safety	31	5,976,378	Rural Development ¹³	14	1,483,333
Epidemiological Approaches to Food Safety ³	6	5,486,155	Total: Markets, Trade, & Rural Development	35	\$3,467,333
Total: Nutrition, Food Safety, & Health	59	\$16,236,991	Enhancing Value and Use of Agricultural and Forest Products		
Animals			Food Characterization/Process/Product Research	21	3,367,883
Animal Reproduction	22	3,888,726	Non-Food Characterization/Process/Product Research	16	2,453,217
Animal Health and Well-Being ⁴	55	10,988,912	Improved Utilization of Wood and Wood Fiber ¹⁴	16	2,025,166
Animal Genome and Genetic Mechanisms	15	2,700,000	Total: Enhancing Value & Use of Agricultural & Forest Products	53	\$7,846,266
Animal Growth, Development, and Nutrient Utilization ⁵	26	3,928,146	Other		
Total: Animals	118	\$21,505,784	Agricultural Systems	11	2,535,289
Biology and Management of Pest and Beneficial Organisms			Strengthening Programs ¹⁵	75	3,514,458
Entomology and Nematology ⁶	33	5,593,143	Metabolic Engineering Program - Interagency ¹⁶	2	250,000
Biology of Plant-Microbe Associations ⁷	26	5,349,010	U.S. Rice Genome Project - Interagency	2	2,000,000
Biologically Based Pest Management ⁸	17	2,494,593	Total: Other	90	\$8,299,747
Biology of Weedy and Invasive Plants	11	2,630,000	Awards to be Determined¹⁷		
Total: Pest Biology and Management	87	\$16,066,746	\$1,620,267		
			GRAND TOTAL		
			597		
			\$99,032,201		

APPENDIX THREE: Quantitative Funding Data for the UGA Department of Poultry Science Obtained from the UGA Office of the Vice President for Research (2001-2005)

2005

POULTRY SCIENCE RSCH COLLEGE

DAVIS, ADAM J				
GA COMMODITY COMM COTTON	50	7,600	DETERMINATION OF GOSSYPOL CONTENT IN COTTONSEED MEAL BY NEAR INFRARED SPECTROSCOPY AND EVALUATION OF THE TOXICITY OF INDIVIDUAL GOSSYPOL ISOMERS	
US POULTRY & EGG ASSOCIATION	50	67,275	IMPROVING REPRODUCTIVE PERFORMANCE OF BROILER BREEDER HENS BY UTILIZING ALTERNATIVE FEEDING PROGRAMS	
FULLER, ALBERTA LORRAINE				
UOFGA RESEARCH FOUNDATION INC	100	1,931	INVENTOR'S RESEARCH PROGRAM	
LACY, MICHAEL P				
US DEPARTMENT OF AGRICULTURE	100	13,203	RESEARCH SUPPORT AGREEMENT 2005	
MCDOUGALD, LARRY R				
UOFGA RESEARCH FOUNDATION INC	100	1,931	TO DISBURSE FUNDS EARNED FROM ROYALTY TO THE INVESTORS RESEARCH PROJECT	
VARIOUS-INCOME	100	7,500	VARIOUS RESEARCH FOR DR. LARRY MCDOUGALD	
RUSSELL, SCOTT M				
VARIOUS-INCOME	100	5,000	VARIOUS INCOME	
VARIOUS-INCOME	100	115	VARIOUS INCOME	
VARIOUS-INCOME	100	3,500	VARIOUS INCOME	
VARIOUS-INCOME	100	2,000	VARIOUS INCOME	

POULTRY SCIENCE

FLETCHER, DANIEL L				
US POULTRY & EGG ASSOCIATION	25	41,400	FRACTIONATION, PROXIMATE ANALYSIS AND CHEMICAL EVALUATION OF SCREENED PROCESSING WASTEWATER PARTICULATE MATTER TO IMPROVE WASTEWATER ...	
LACY, MICHAEL P				
US DEPARTMENT OF AGRICULTURE	100	-9,864	TASK ORDER	
US DEPARTMENT OF AGRICULTURE	100	12,770	ANIMAL HEALTH AND DISEASE	
US POULTRY & EGG ASSOCIATION	100	12,461	SPEA FDN CHERAY	
VARIOUS-INCOME	100	3,863	DISCR-VAR-CHERRY PI CHGD TO DEPT HEAD 04/21/03 - M P LACY	
VARIOUS-INCOME	100	400	DISCR-VAR-CHERRY PI CHGD TO DEPT HEAD 04/21/03 - M P LACY	
VARIOUS-INCOME	100	50	DISCR-VAR-CHERRY PI CHGD TO DEPT HEAD 04/21/03 - M P LACY	
PESTI, GENE M				
GA COMMODITY COMM PEANUTS	100	5,000	PEANUT MEAL FOR COMMERCIAL EGG PRODUCTION	
GA COMMODITY COMM PEANUTS	100	5,000	PEANUT MEAL FOR COMMERCIAL BROILER DIETS	

2004

POULTRY SCIENCE RSCH COLLEGE

AGGREY, SAMUEL E US POULTRY & EGG ASSOCIATION	80	82,800	EVALUATION OF GENES RESPONSIBLE FOR PHYTATE PHOSOPHORUS UTILIZATION (PPU) IN POULTRY
BATAL, AMY BETH GA COMMODITY COMM PEANUTS US POULTRY & EGG ASSOCIATION	50 50	6,000 30,000	CORRECTING THE NUTRIENT VALUES OF PEANUT MEAL FOR POULTRY AND ANIMAL FEEDS EFFECT OF WATER QUALITY ON BROILER PERFORMANCE
FULLER, ALBERTA LORRAINE UOFGA RESEARCH FOUNDATION INC	100	0	TO DISBURSE FUNDS EARNED FROM ROYALTY TO THE INVENTORS RESEARCH PROJECT.

POULTRY SCIENCE

EDWARDS JR, HARDY M US POULTRY & EGG ASSOCIATION	50	58,075	INVESTIGATING OF THE CAUSE OF THE VARIABLE RESONSES TO PHYTASE APPLEMENTATION OF THE DIET ON ENERGY AND PROTEIN UTILIZATION
LACY, MICHAEL P US DEPARTMENT OF AGRICULTURE	100	13,959	ANIMAL HEALTH AND DISEASE RESEARCH FUNDS FOR FISCA L YEAR 2003
US DEPARTMENT OF AGRICULTURE	100	25,300	TASK ORDER
US POULTRY & EGG ASSOCIATION	100	11,060	SPEA FDN CHERAY
VARIOUS-INCOME	100	2,000	DISCR-VAR-CHERRY PI CHGD TO DEPT HEAD 04/21/03 - M P LACY
PESTI, GENE M US POULTRY & EGG ASSOCIATION	50	58,075	INVESTIGATING OF THE CAUSE OF THE VARIABLE RESONSES TO PHYTASE APPLEMENTATION OF THE DIET ON ENERGY AND PROTEIN UTILIZATION
US POULTRY & EGG ASSOCIATION	20	82,800	EVALUATION OF GENES RESPONSIBLE FOR PHYTATE PHOSOPHORUS UTILIZATION (PPU) IN POULTRY

2003

POULTRY SCIENCE RSCH COLLEGE

MARKS, HENRY LEWIS UOFGA RESEARCH FOUNDATION INC	100	841	INDIRECT COST RETURNS
MCDUGALD, LARRY R VARIOUS-INCOME	100	1,298	RESEARCH ON MICROBIOLOGY OF HARD COOKED EGGS
VARIOUS-INCOME	100	150	RESEARCH ON MICROBIOLOGY OF HARD COOKED EGGS
VARIOUS-INCOME	100	40,000	VARIOUS RESEARCH FOR DR. LARRY MCDUGALD
VARIOUS-INCOME	100	23,000	VARIOUS RESEARCH FOR DR. LARRY MCDUGALD
RUSSELL, SCOTT M VARIOUS-INCOME	100	3,600	VARIOUS INCOME
VARIOUS-INCOME	100	3,600	VARIOUS INCOME
WYATT, ROGER D VARIOUS-INCOME	100	15,000	GIFT FOR RESEARCH ON MOLD GROWTH AND MOLD RETARDANTS IN FEED INGREDIENTS AND POULTRY FEEDS
VARIOUS-INCOME	100	7,500	GIFT FOR RESEARCH ON MOLD GROWTH AND MOLD RETARDANTS IN FEED INGREDIENTS AND POULTRY FEEDS

POULTRY SCIENCE

DAVIS, ADAM J				
GA COMMODITY COMM COTTON	50	12,000	MARKET DEVELOPMENT: DEFINING THE USE OF COTTONSEED MEAL IN BROILER BREEDER PULLET DIETS	
FLETCHER, DANIEL L				
US POULTRY & EGG ASSOCIATION	100	28,175	ANIMAL WELFARE ASPECTS OF POULTRY SLAUGHTER	
LACY, MICHAEL P				
US DEPARTMENT OF AGRICULTURE	100	15,232	ANIMAL AND HEALTH DISEASE FUNDS FOR FY2002	
US POULTRY & EGG ASSOCIATION	100	10,816	SPEA FDN CHERAY	
VARIOUS-INCOME	100	500	DISCR-VAR-CHERRY PI CHGD TO DEPT HEAD 04/21/03 - M P LACY	
PESTI, GENE M				
GA COMMODITY COMM PEANUTS	100	4,000	THE UTILIZATION OF PEANUTE MEAL IN LAYING HEN DIET	
GA COMMODITY COMM PEANUTS	100	3,000	BALANCING DIETS TO UTILIZE PEANUT MEAL IN COMMERCIAL EGG PRODUCTION	
GA COMMODITY COMM PEANUTS	100	4,000	PEANUT MEAL FOR COMMERICAL BROILER PRODUCTION	

2002

POULTRY SCIENCE RSCH COLLEGE

DALE, NICHOLAS M				
US POULTRY & EGG ASSOCIATION	25	26,450	REDUCING BODY FAT SYNTHESIS IN BROILER CHICKENS THROUGH USE OF SPECIFIC AMINO ACID DIETARY PROFILE S	
DAVIS, ADAM J				
US POULTRY & EGG ASSOCIATION	75	26,450	REDUCING BODY FAT SYNTHESIS IN BROILER CHICKENS THROUGH USE OF SPECIFIC AMINO ACID DIETARY PROFILE S	
EDWARDS JR, HARDY M				
US POULTRY & EGG ASSOCIATION	55	55,085	DETERMINATION OF THE VITAMIN D REQUIREMENT OF BROILER BREEDER HENS	
MARKS, HENRY LEWIS				
UOPGA RESEARCH FOUNDATION INC	100	261	INDIRECT COST RETURNS	
VARIOUS-INCOME	100	1,000	DISCR-VAR-CHERRY	
VARIOUS-INCOME	100	1,000	DISCR-VAR-CHERRY	
MCDUGALD, LARRY R				
VARIOUS-INCOME	100	37,500	RESEARCH ON MICROBIOLOGY OF HARD COOKED EGGS	
VARIOUS-INCOME	100	32,000	RESEARCH ON MICROBIOLOGY OF HARD COOKED EGGS	
VARIOUS-INCOME	100	300	RESEARCH ON MICROBIOLOGY OF HARD COOKED EGGS	
VARIOUS-INCOME	100	43,500	VARIOUS RESEARCH FOR DR. LARRY MCDUGALD	
PESTI, GENE M				
US POULTRY & EGG ASSOCIATION	45	55,085	DETERMINATION OF THE VITAMIN D REQUIREMENT OF BROILER BREEDER HENS	
RUSSELL, SCOTT M				
VARIOUS-INCOME	100	1,860	VARIOUS INCOME	
VARIOUS-INCOME	100	1,860	VARIOUS INCOME	
WYATT, ROGER D				
VARIOUS-INCOME	100	7,500	GIFT FOR RESEARCH ON MOLD GROWTH AND MOLD RETARDANTS IN FEED INGREDIENTS AND POULTRY FEEDS	
VARIOUS-INCOME	100	7,500	GIFT FOR RESEARCH ON MOLD GROWTH AND MOLD RETARDANTS IN FEED INGREDIENTS AND POULTRY FEEDS	
VARIOUS-INCOME	100	100	GIFT FOR RESEARCH ON MOLD GROWTH AND MOLD RETARDANTS IN FEED INGREDIENTS AND POULTRY FEEDS	
VARIOUS-INCOME	100	22,500	GIFT FOR RESEARCH ON MOLD GROWTH AND MOLD RETARDANTS IN FEED INGREDIENTS AND POULTRY FEEDS	
VARIOUS-INCOME	100	7,500	GIFT FOR RESEARCH ON MOLD GROWTH AND MOLD RETARDANTS IN FEED INGREDIENTS AND POULTRY FEEDS	
<u>POULTRY SCIENCE</u>				
DAVIS, ADAM J				
GA COMMODITY COMM COTTON	50	12,000	POTENTIAL USE OF COTTONSEED MEAL IN BROILER BREEDER PULLET FEEDS	
LACY, MICHAEL P				
GA INSTITUTE OF TECHNOLOGY	25	7,000	ENERGY EFFICIENT BROODING IN BROILER HOUSES	
US POULTRY & EGG ASSOCIATION	100	13,656	SPEA FDN CHERAY	
RUSSELL, SCOTT M				
US POULTRY & EGG ASSOCIATION	100	23,177	PREVENTION OF SALMONELLA CONTAMINATION OF READY- TO-COOK POULTRY USING AN ELECTROSTATIC SPRAYING SYSTEM TO ELMINATE SALMONELLA FROM... FERTILIZED HATCHING EGGS AND HATCHERY ENVIRONMENTS	
US POULTRY & EGG ASSOCIATION	100	24,706	RECYCLING POULTRY PROCESSING SCALD WATER USING ULTRAFILTRATION AND DISINFECTION	

2001

POULTRY SCIENCE RESEARCH - COLLEGE

AGGREY, SAMUEL EGYR UNIVERSITY OF DELAWARE	100	210,000	A CONSORIUM OF FUNCTIONAL MAPPING OF GROWTH REGULATING GENES IN BROILER CHICKENS
US POULTRY & EGG ASSOCIATION	70	37,950	ESTABLISHING GENETIC BASIS AND SELECTION FOR PHYTATE PHOSPHORUS UTILIZATION IN CHICKENS
EDWARDS JR, HARDY M US POULTRY & EGG ASSOCIATION	40	20,700	PHOSPHORUS AND NITROGEN IN BROILER LITTER: NIRS CALIBRATION AND COOPERATIVE TEST OF PHYTASE EFFECTIVENESS
LACY, MICHAEL P US DEPARTMENT OF AGRICULTURE	100	15,362	ANIMAL AND HEALTH DISEASE FUNDS FOR FISCAL YEAR 20 01
MARKS, HENRY LEWIS UOFGA RESEARCH FOUNDATION INC	100	625	INDIRECT COST RETURNS
US DEPARTMENT OF AGRICULTURE	100	15,527	ANIMAL AND HEALTH DISEASE FUNDS FOR FISCAL YEAR 20 00
MCDUGALD, LARRY R VARIOUS-INCOME	100	20,000	VARIOUS INCOME
VARIOUS-INCOME	100	500	RESEARCH ON MICROBIOLOGY OF HARD COOKED EGGS
VARIOUS-INCOME	100	7,955	RESEARCH ON MICROBIOLOGY OF HARD COOKED EGGS
VARIOUS-INCOME	100	2,250	RESEARCH ON MICROBIOLOGY OF HARD COOKED EGGS
MERKA, WILLIAM C US POULTRY & EGG ASSOCIATION	45	18,400	PROFILE AND PRODUCTION PROCESS DETERMINATION OF PHOSPHORUS AND NITROGEN WASTEWATER DISCHARGES FROM POULTRY PROCESSING PLANTS
US POULTRY & EGG ASSOCIATION	45	17,250	PARTICLE SIZE ANALYSIS OF SECONDARY SCREENED POULTRY PROCESSING WASTEWATER WITH PREDICTIVE EVALUTATION OF TERTIARY SCREENING TO REDUCE DAF SOLIDS
PESTI, GENE M US POULTRY & EGG ASSOCIATION	60	20,700	PHOSPHORUS AND NITROGEN IN BROILER LITTER: NIRS CALIBRATION AND COOPERATIVE TEST OF PHYTASE EFFECTIVENESS
US POULTRY & EGG ASSOCIATION	30	37,950	ESTABLISHING GENETIC BASIS AND SELECTION FOR PHYTATE PHOSPHORUS UTILIZATION IN CHICKENS
RUSSELL, SCOTT M VARIOUS-INCOME	100	1,200	VARIOUS INCOME
VARIOUS-INCOME	100	868	VARIOUS INCOME
WYATT, ROGER D VARIOUS-INCOME	100	15,000	GIFT FOR RESEARCH ON MOLD GROWTH AND MOLD RETARDANTS IN FEED INGREDIENTS AND POULTRY FEEDS
VARIOUS-INCOME	100	15,000	GIFT FOR RESEARCH ON MOLD GROWTH AND MOLD RETARDANTS IN FEED INGREDIENTS AND POULTRY FEEDS
VARIOUS-INCOME	100	7,500	GIFT FOR RESEARCH ON MOLD GROWTH AND MOLD RETARDANTS IN FEED INGREDIENTS AND POULTRY FEEDS
VARIOUS-INCOME	100	7,500	GIFT FOR RESEARCH ON MOLD GROWTH AND MOLD RETARDANTS IN FEED INGREDIENTS AND POULTRY FEEDS
VARIOUS-INCOME	100	7,500	GIFT FOR RESEARCH ON MOLD GROWTH AND MOLD RETARDANTS IN FEED INGREDIENTS AND POULTRY FEEDS
<u>POULTRY SCIENCE</u>			
FLETCHER, DANIEL L US POULTRY & EGG ASSOCIATION	30	28,773	RELATIONSHIP BETWEEN BROILER FLOCK CAMPYLOBACTER SALMONELLA STATUS, TRANSPORTATION CROSS CONTAMINATION FEED WITHDRAWAL CONDITION AND CARCASS MICROBIOLOGICAL CHARACTERISTICS
MARKS, HENRY LEWIS US POULTRY & EGG ASSOCIATION	100	12,389	SPEA FDN CHERAY

APPENDIX FOUR: Interview Questions:

--What is the focus of your current research project(s)?

--What factors influenced your decision to pursue this particular research issue – e.g. general intellectual interest; feasibility, availability of funding; likelihood of publication; the issue's salience within the poultry science research community; other? (This will elicit how the interviewee sees his/her work within the context of the research community and his/her reasons for choosing their research topic.)

--By whom is your research being funded?

--Who are the most significant sources of funding for poultry science research? (There will be a degree of subjectivity in the individual responses. Taken collectively, a general consensus among interviewees will suggest a relatively clear-cut funding community. Absence of consensus will suggest a more opaque situation.)

--How did you decide to which funding sources you would apply? (This will identify the researcher's perceptions of the funding sources relevant to his/her topic. It will also help to identify self-selection of sources by the researcher.)

--Ideally, the rule of thumb with regard to the acquisition of funding for scientific research is that proposals will be judged according to their scientific merit. Sound research will tend to be funded while less rigorously designed research will not. Everything else being equal, however, has it been your experience that certain research topics are more likely to receive funding than other topics? If so, why do you believe this to be the case? (The collective responses to this question will bring into focus patterns of funding preference by research topic.)

--Are you aware of any instances in which research projects, yours or those of others, were left unfunded in spite of their scientific merit? If so, why do you believe this was the case? (This will serve as a follow up to the previous question, with the aim of obtaining more specific information.)

--Are there research areas which you believe are worthy of greater study but for which little, if any, funding is available? If so, how do you account for the dearth of funding? (This will allow the interviewee to express his/her general thoughts/frustrations on the funding issue.)

--What are the criteria by which faculty in this department are assessed when tenure/promotion is decided? In particular, how critical is the attainment of research funding for tenure/promotion? (The aim of this question is to confirm the significance of obtaining research funding for professional advancement.)

APPENDIX FIVE: Letter of Introduction to Poultry Science Faculty

Would you be available for a brief interview relating to my Thesis research?

My name is Mitch Chapura and I am a graduate student in the Department of Geography here at UGA. My Master's Thesis research includes an examination of certain aspects of the contemporary poultry industry. Given Georgia's status as a key poultry producing region of the world, and the importance of the University of Georgia's Department of Poultry Science to Georgia's poultry industry, I am particularly interested in better understanding poultry science research here at UGA. I am writing to invite you to help facilitate my research by participating in a brief interview. The interview should last between 10 and 30 minutes. The results of the research may be published, but all information obtained during the interview will remain anonymous.

While meeting in person would be ideal, if such a meeting proves inconvenient, I would be happy to schedule an interview by phone, or to send you my interview questions as an e-mail attachment, to which you may then respond in writing at your leisure. If you would like to participate, or if you have any questions, please reply by e-mail at your earliest convenience.

Sincerely,

Mitch Chapura

