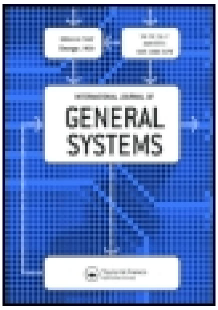

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Culture in cycles: considering H.T. Odum's 'information cycle'

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Culture in cycles: considering H.T. Odum's 'information cycle'

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'Culture' remains a conundrum in anthropology. When recast in the mold of 'information cycles,' culture is transformed. New fault lines appear. Information is splintered into parallel or nested forms. Dynamics becomes cycling. Energy is essential. And culture has function in a directional universe. The 'information cycle' is the crowning component of H.T. Odum's theory of general systems. What follows is an application of the information cycle to the cultural domains of discourse, social media, ritual, education, journalism, technology, academia, and law, which were never attempted by Odum. In information cycles, cultural information is perpetuated – maintained against Second Law depreciation. Conclusions are that culture is in fact a nested hierarchy of cultural forms. Each scale of information production is semi-autonomous, with its own evolutionary dynamics of production and selection in an information cycle. Simultaneously, each information cycle is channeled or entrained by its larger scale of information and ultimately human-ecosystem structuring.

Keywords: culture; information cycle; cultural evolution; hierarchy; scale; self-organization

1. What is culture?

Within anthropology, culture as a topic has never held still. Countless efforts have been made to define culture, including the 164 definitions once collected into a book by two prominent anthropologists (Kroeber and Kluckhohn 1952). Today, culture can be found at the same time in a number of forms. For instance, in evolutionary anthropology, culture is divided into traits of knowable frequencies, and methods from population genetics are applied (Richerson and Boyd 2005). In postcolonial anthropology, culture may be a fluid, often contested, and only partially integrated mosaic of narratives, images, and signifying practices (Comaroff and Comaroff 1991). In cognitive anthropology, culture is composed of particulate schemas or cultural models that are socially distributed, variously internalized, and embodied in connectionist minds and in material objects (D'Andrade 1995). In environmental anthropology, it is still possible to read occasionally that culture is an adaptive behavioral system of objects, organization, economy, and ideas (Bates 2005), but such instrumental and system-scale conceptualizations are in the minority. What explains the diversity of meaning, and is there any hope for reconciliation?

A little more history is first required before that question can be addressed. In the earlier years of anthropology, culture was seen as an integrated system of action, belief, and object, "that complex whole which includes knowledge, belief, art, law, morals, custom, and any other capabilities and habits acquired by man as a member of society" (Tylor [1871] 1974). Analogies were made by some anthropologists to language grammar with its unconscious rules and unique patterning in every language and people (Benedict 1934; Boas 1911). But

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most often, in the early years, culture was conceived functionally or instrumentally, seen to be just one more layer of evolutionary adaptation (Morgan 1877; Spencer 1876). The nature of the adaptation varied across a number of schools of anthropology. For some, the customs of culture met human basic needs (Malinowski 1939) and for others, customs contributed to a stable and functioning society (Radcliffe-Brown 1940); for some ecological anthropologists, customs contributed to human-ecosystem balance (Rappaport 1968); and for the conflict theorists, culture (often unnamed) was an integrated system of production including social relations and related (disciplinary) modes of thought.

In the last quarter of the last century, following an intellectual upheaval of sorts, at least in America, the meaning of culture has narrowed, from an integrated system of organization, economy, technology, and related ideas, to those ideas alone, shared by a population, meanings that we co-construct and hold together in a group or groups. Today, anthropology is less inclined to see system and function in culture and more willing to expect contestation, negotiation, and a diversity of often conflicting formations of thought (Foucault 1980). Meaning, both in mind and bodily practice, related to power – not shared customs – is the stuff of culture for many anthropologists today (Bourdieu 1977), though not all. Its formation is discursive and dynamic, with room for resistance (Gramsci and Buttigieg 1992). Today, culture is difference, not consensus (Asad 1979; Keesing 1987), not bounded, timeless, or determinative (Abu-Lughod 1991), outside of direct experience, but imagined (Strathern 1996; Thornton 1988), it includes global flows of images, people, commodities, and capital (Appadurai 2000), and is often a mobilizing symbol for indigenous groups and others (Jackson 1995).

I feel an understanding of culture can accommodate this range of culture concepts, particulate but also whole, contest but also function. These seemingly disparate parts are reconciled when two considerations are entertained. In this paper, I will argue that the information of culture is hierarchical, reflecting the multi-scaled, hierarchical organization of human mind. Second, I will show that culture is produced in a hierarchy of distinct production processes, and that these processes interact in comprehensible and indeed instrumental fashion as ideas self-organize with our larger human political-economic and ultimately ecological context.

The dozen or so distinctly different processes of cultural production that have come into existence differ along a number of essential dimensions – the amount of work required for their production, their energy and material inputs, the impact that each delivers, their cycle time and space, the number of acts of production, and the fidelity of intermediate 'carriers.' These distinctions in the production of culture result in its hierarchical pattern of assembly. We can name scales of cultural production because they are familiar to us. Mass media, classroom lecture, social media, ritual, scientific publication, market reports, judicial decrees, and arguably others, these may all be (oddly) construed as discourse. But much is lost by that. The various scales of cultural hierarchy are produced in different ways, with characteristic energies and materials at each scale. The varied outputs of cultural production differ in the impacts they can deliver on the whole of people-economy-nature. Cultural forms are produced in continuous cycles of production and reproduction, within 'information cycles' as will be explained, but cycle times and space vary greatly across scales. Cultural production at one scale is often initiated by information from other scales. The construction of culture is indeed an open, dynamic, and contentious process, but also one that is hierarchical and instrumental. These and related claims will be made and defended throughout the paper.

2. Complexity, self-organization, and information

The perspective of this paper is scientific anthropology. It is, in fact, complex systems science. As will be seen, this paper will invoke many of the meta-narratives of science that have been critiqued within anthropology and other fields (science and technology, critical theory, etc.), and it will defend that position in later sections. Complex systems science today takes a number of related forms. Some are explicitly computational, focusing on genetic algorithms (Holland 1995), Boolean networks (Kauffman 1993), multi-agent modeling (Axelrod 1997; Epstein and Axtel 1996; Gilbert and Conte 1995), or fractal geometry (Mandelbrot and Freeman 1983). Another major area of focus is the energetic self-organization of open thermodynamic systems (Odum 1988). As my interest is in the production of cultural information, and especially in the energy and materials that distinguish the (self-organizing, emergent) processes of culture construction, my focus will be on this facet of complex systems research.

Self-organization is argued to be a fundamental phenomenon of nature, the result of nature's thermodynamic arrow in time (Prigogine and Stengers 1984). Once labeled 'heat death,' nature's entropic directionality from concentration to dissipation is now recognized to be a creative force by which self-organized structures appear (Schneider and Sagan 2005; Wicken 1987). Especially ecologists and biosphere scientists have found value in exploring the characteristic structures and cycles related to energy capture and use in biophysical systems (Allen and Starr 1982; Depew and Weber 1995; Gunderson and Holling 2002; Jørgensen and Müller 2000; Kay and Schneider 1994; Kleidon 2004; Levin 1998; Odum 2007; Salthe 1993; Ulanowicz 1997; Volk 1998). Exploring self-organization in chemical reactions, organisms, ecosystems, and the biosphere, these researchers have revealed the form and dynamics of these pervasive systems, which were only widely recognized as natural phenomena in the last half century.

As this paper will explore the 'information cycle' of Odum (1996), I should expand briefly on his distinct characterization of complex systems. For Odum, self-organization is fundamentally a constructive process. From his extensive study of systems of all kinds (1983), but particularly ecosystems, Odum, following Lotka (1922), contends that in self-organization, systems develop those parts, processes, and relationships that capture the most energy. vFurthermore, self-organized systems use their energy with the best efficiency possible without reducing power; that is, the flow of energy through the system. This fundamental principle of self-organization he has labeled 'maximum-empower.' Further still, ecosystems and all systems are organized internally as hierarchies (e.g. food chains), and can be located within a universal hierarchy of energy transformations. These two basic principles, maximum-empower and the hierarchy principle, he proposed to be the Fourth and Fifth Laws of Thermodynamics (1996, 16). I will return to these principles elsewhere in the paper. Additional characteristics of the energy transformation hierarchy will be introduced and discussed below.

3. The function of information

Tornados, deep ocean gyres, Earth mantel convection cells, and typhoons are self-organized, thermodynamic structures. When a self-organized structure looses its energy source, as when a typhoon moves onshore, its structure is quickly lost. The next typhoon must start again from nothing as it slowly finds its form.

With the appearance of life on Earth has come something that makes a dramatic contribution to this universal process of self-organization, something that we generically call information. The genetic information of life allows self-organized structure to last in time and extend in space, to ride-out the many natural fluctuations in energy sources (e.g. day/night, seasons, etc.) (Wicken 1987). With the appearance of life, time-tested energy pathways are preserved from day-to-day, and much longer, by the information of genetics and its blueprint for both living and reproduction. H. T. Odum makes these points in abbreviated form:

> The geobiosphere builds and maintains structural storages with productive work … When inputs decrease, nonliving structures dissipate, and later if energy inputs are again available, self-organization has to start over. With information the products of self-organization carry over from one episode of growth to another, making life, progress, and evolution possible. (Odum 2007, 221)

With the evolution of we humans, another form of information has appeared. Culture performs this same trick of persistence and expansion with additional efficiency (Odum 2007), perhaps ideally suited to environments that fluctuate at specific rates that were encountered by human evolution (Richerson and Boyd 2005, 131). Cultural information is like and unlike genetic information. H. T. Odum has explored the similarities and differences and has produced a synthetic theory of information, nested within his theories of general systems. In his approach, information is maintained only within what he calls information cycles (or circles). He has diagrammed information cycles in a number of ways, of which this diagram is representative (Figure 1) (Odum 1996, 223).

From Odum's view, information cannot be created once and then copied through time from one individual to another:

> Because information has to be carried by structures, it is lost when the carriers disperse (second energy law) … Information is maintained by copies made faster than they are lost or become non-functional. But copying from one original is not enough because errors develop (second law), and copying doesn't make corrections.
>
> So in the long run, maintaining information requires a population operating an information copy and selection circle like that in Figure 1. The information copies must be tested for their utility.

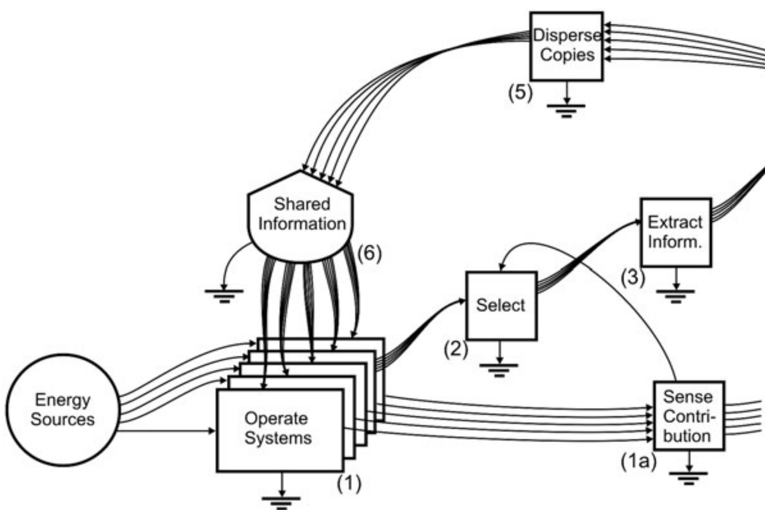

Figure 1. The information cycle. In an information cycle, 'the plans (information) for successful systems are extracted, copied, distributed, and used to make more structure to operate systems' (Odum 2007, 225). When applied to DNA information, this is a lifecycle, with selection for breeding adults, reproduction, and the dispersal of seed, egg, or offspring. Note that each 'process' box and 'storage' tank has a heat sink. This indicates that work is done and energy from the 'Energy Sources' has been dissipated. In each 'process' box, there has been some transformation. In the one storage, there is simply maintenance against depreciation; with new information entering as old is lost by natural processes of information degradation. Figure after Odum (1996, 223), step numbers added, used with permission.

> Variation occurs in application and use because of local differences and errors. Then the alternatives that perform best are selected and the information of the successful system is extracted again. Many copies are made so that the information is broadly shared and used again, completing the loop. In the process, errors are eliminated, and improvements may be added in response to the adaptation to local variations …

> In an information circle, the information is increased with copying and decreased with selections and depreciation, but a successful circle maintains enough copies to exceed depreciation and destruction rates. (2007, 88–89)

In an information cycle, therefore, information must be transmitted through time via many copies (Step 4, Figure 1), via a population of carriers bearing that information. Each new copy is dispersed (5) within the system where it does what it does, always within a larger, dynamic, multi-scaled system (6) of energy and materials. Note that in any cycle, the role of the entity may shift, a result of the dynamic and infinitely complicated nature of its nested context. Successful copies may be later selected (2) for a new round of information extraction (3), copying (4), and dispersal (5) as the cycle repeats.

While Odum did elaborate the lifecycles of rainforest trees (Odum and Odum 2001, 72), of salmon (Odum 2007, 228), and of shrimp (Odum 1996, 228) as information cycles, he never provided a detailed account of the formation of cultural information, which would include identifying the roles of actors such as parents, academics, or journalists. In this paper, I will explore Odum's understanding of information and will take it where it has not yet been. I will offer new applications of the information cycle to a wide range of forms of cultural information, utilizing cognitive, social, evolutionary, etc. theory that is available within disciplines most associated with each information form. This presents some challenge, spanning disciplines is always difficult, and within each lays the task of applying the information cycle in a well enough reasoned application. The outcome will be a new, perhaps dramatically new, approach to the study of culture produced at multiple scales in a hierarchy of information.

4. The hierarchical organization of culture and mind

In my opening section, I stated that culture is a hierarchical organization of information that reflects the organization of knowledge in mind. Great progress has been made in recent years in the study of brain biology. Much work remains, however, to demonstrate the organization of knowledge in the organs of the brain. I propose a hierarchical organization of knowledge that you will see is compatible with known brain neuropsychology and simultaneously connectionist cognitive theory (e.g. Nalbantian, Matthews, and McClelland 2010), and I go into some detail, for implications here will be important for the study of discourse and other scales of culture production.

In contemporary cognitive and neuroscience, it is common to differentiate between explicit and implicit memory, and within the former between semantic and episodic memory (Tulving 1985). Implicit (or non-declarative) memory may be the product of a number of different brain areas and take different forms and functions, such as the formation of skills or habits, emotional responses, skeletal responses, and priming and perceptual learning (Baars and Gage 2007). Episodic memories are memories for particular events in time and include details of context and events. Semantic memory is memory for what we commonly label as 'facts' or 'ideas.'

Both semantic and episodic memories are conceived as explicit memory, while we possess implicit memories for habitual learning of skills, emotional responses, skeletal responses, etc. (Tulving 1985). This conceptual division of labor may be unsatisfactory for social scientists who for a century have been exploring the nature of cultural knowledge (a more agreeable neuropsychological approach comes from (Henke 2010). For decades, anthropologists, linguists, sociologists, and others have proposed the existence of implicit cultural knowledge that shapes or channels or constrains explicit thought in some fashion or another. With the current state of neuroscience, research is only beginning to address "what the animal itself brings in the way of knowledge to a learning situation" (Tse et al. 2007, 76), and it is likely that neuroscientists are unaware of the great depth and variety of unconscious codes, models, rules, or broader configurations (e.g. habitus) that have been identified through varieties of qualitative 'discovery' procedures by social scientists.

With connectionism and neuropsychology, we now have science that emphasizes the associative learning of experienced knowledge. It is, therefore, possible to reconceive the formation of (some forms of) implicit knowledge via the experiences of explicit memory formation. During especially our early enculturation experiences, through rounds of interpersonal interaction, we gradually construct and reconstruct explicit semantic knowledge of the world. Simultaneously, over time, we are building additional layers or scales of knowledge that filter or structure new experience, and that are largely implicit (Figure 2). An obvious though controversial example is the grammatical structure of a language, which is an implicit knowledge hierarchy that arguably is the product of statistical learning over countless rounds of language experience (Pelucchi, Hay, and Saffran 2009; Saffran 2003).

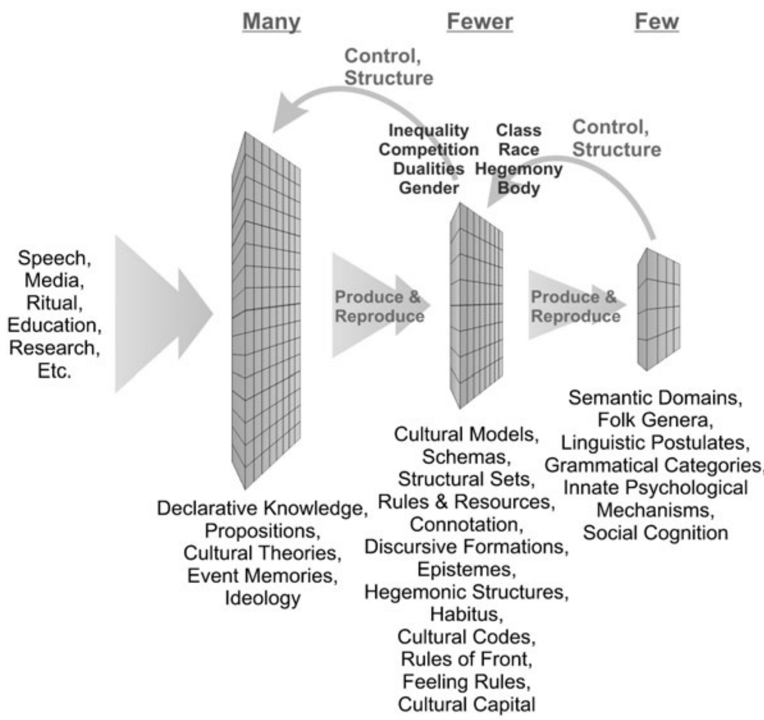

Figure 2. Functional model of human memory and cultural knowledge. This diagram depicts a functional model (not anatomical) of human memory, and the number of scales is only suggestive. As in other hierarchies, there are many events to the left, fewer in the middle, and fewer still to the right. While some objects to the right have an innate component, their expression is a 'product' of those to the left. Simultaneously, objects to the right feedback to control or structure or constrain those on the left.

In a similar fashion, we should suggest that the implicit forms of knowledge that have been proposed by social scientists as underlying and structuring explicit thought may also be the product of early, especially, and later rounds of interpersonal interactions. The formation of cultural models (Holland and Quinn 1987), habitus (Bourdieu 1977), rules and routines (Giddens 1984), discursive formations (Foucault 1980), etc., just as grammar, may be statistical products of input that over time constitute another 'layer' or scale in a hierarchy of cultural knowledge (Figure 2). This layer depends further on the presence of the still deeper layer(s) of grammar (Hardman-de-Bautista 1978; Levinson 2003), domain-specific attractors (Sperber 1996), social cognition (Baron-Cohen 1995), and innate psychological mechanisms as proposed by evolutionary psychologists (Barkow, Cosmides, and Tooby 1992). The information forms that are implicit constitute our 'rails of thought,' the unconscious taken-for-granted understandings of the world that language communities and society members share in parts.

This hierarchy can be seen to possess general properties of hierarchies that have been described by Odum (1996, 24). Through the statistical learning associated with many, many interpersonal interactions and episodic memories, fewer cultural models, codes, etc. are formed, and fewer still underlying grammatical categories take shape. The structures to the right change slowly (long turnover times), apply to the countless interaction inputs (they have a large 'spatial' scale), require constant reconstruction through each round of memory reconsolidation (have a higher 'maintenance cost'), and can apply to the great diversity of interaction inputs. Finally, as in other hierarchies, the larger scales control or structure the production and timing of behaviors to their left (feedback arrows).

5. A hierarchy of cultural production processes

The previous discussion of cultural knowledge has been a means to an end. While perhaps of value in itself, my principal intention has been to set the stage for the following account of the hierarchy of production processes of cultural information. It was necessary first, however, to make clear that my understanding of cultural 'information' is not simplistic, and thus that the processes of cultural production described below do not address simply snippets of declarative knowledge, for example, but rather refer simultaneously to the construction and maintenance of unconscious knowledge structures, those structures that experienced anthropologists know must be included in any conceptualization of 'culture.' I hope I have shown that those knowledge structures, habitus, cultural models, hegemonic structures, etc. are continuously being produced and reproduced as they are applied in human discourse. What I hope now to demonstrate is that human discourse is only one of many scales of culture production.

I will begin my exploration of the hierarchy of cultural production processes by jumping into the middle. I take this approach because these first two scales are familiar to us all, which should aid explication of that which is new.

5.1. The news media

Two very influential streams of cultural information that have occupied Odum and countless other observers are those labeled news media and science (or scholarly research). Many writers have great hope for the role of science in improving life, while journalism is often decried, or tolerated at best. How could they be conceived as distinct scales of cultural production and represented in Odum's information cycle, and what are the implications of doing so?

Odum never located specific persons or roles within his information cycle since he had not yet attempted to explore 'cultural' information in detail. In Figure 3, I have chosen to situate journalists as the extractors and processors of information (3). They observe the world and narrate points of interest. But, they do not see the world in a pristine sense; it is filtered or selected (2) by the larger scaled context of market elites, production chains, newsroom managers, ecological context, academic elites, and others, often called the gatekeepers in journalism studies (Shoemaker et al. 2001) (1a). The story subject, message, and style are largely selected or framed (Scheufele 1999) by this context. From this filtered world, the journalists extract (3) points of information for the production of their stories. Once written, stories are made in many copies (4). This is the first point where the significant energies and technologies of media corporations are applied ('storage' and energy 'source' added). Beginning with the first printing presses, these technologies make it possible to produce great volumes of story copies. At the next step in the information cycle is the second powerful innovation, the application of new transmission technologies for the dispersal (5) of news stories. This technology also requires substantial energy inputs, which are shown as another energy source. Finally, information is shared among viewers, readers, etc. (6). Not all members of society are exposed to all stories, and certainly not all members assimilate the information in the same way or at all.

What happens as the cycle ends is important. As we know, TV news is often a cacophony of similar stories, all related to the first 'breaking' story. While one cycle is the end of one story, it has entered the larger complex world. Here, its impact is unknowable. But due to the energy and technologies of copy and transmission, the story is shared widely and may influence information cycles at any scale, including again the TV news scale, where the essence of the story is extracted by perhaps additional reporters from other networks, sharing the information among many more viewers. This type of information copying is imprecise. I will argue below that it constitutes a form of statistical learning. Furthermore, what is learned is

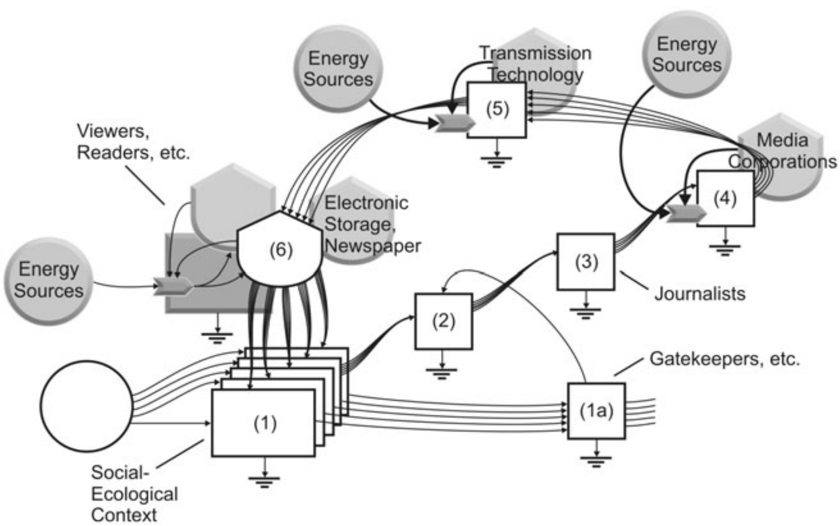

Figure 3. Information in the news media. The news media cycle is fast. Carriers are not people, but are paper or electronic signals. The cycle is dependent on the added energies and technologies of media corporations, transmission mechanisms, and electronic storage ('storages' and energy 'sources' added). Stories are selected by gatekeepers and produced by journalists.

not only explicit story content but also implicit form, ritual, affect, and model, which constitute and reconstitute the higher scales of cultural knowledge in mind (Figure 2).

Last, in biological reproduction, genetic information is tied to the organism's lifecycle and thus the cycling of genetic information is very slow in time. But certainly, news stories are not selected with the individual who bares them. The journalism information cycle, as we know, is extremely fast, requiring only minutes or hours to complete at times, and its 'carrier' is paper or electromagnetic wave.

5.2. Science and academic research

In the scholarly research information cycle (Figure 4), researchers (of science, literature, history, markets, etc.) are the extractors and processors of information (3). Researchers, H.T. Odum for example, look at the complex world and conduct research. But once again, the focus and practice of research has been selected (2) by the larger context, which, as recently explored by Science & Technology researchers, includes the conventions embodied in research sites, the organizational setting of academia, epistemic cultures, devices of representation, etc. (Knorr-Cetina 1999; Merz 2005), and which is all, arguably, structured by the larger political-economic-ecological context of academia (1a). The products of research are publications of results, literary works, market reports, etc. The works are then copied, again with the advanced copying technologies available in publication houses (4) (energy source and storage added). Copies are then dispersed (5); many of which go to libraries in America and around the world (energy source and storage again added), but some now also go to electronic repositories connected to the web. Libraries are important and sophisticated

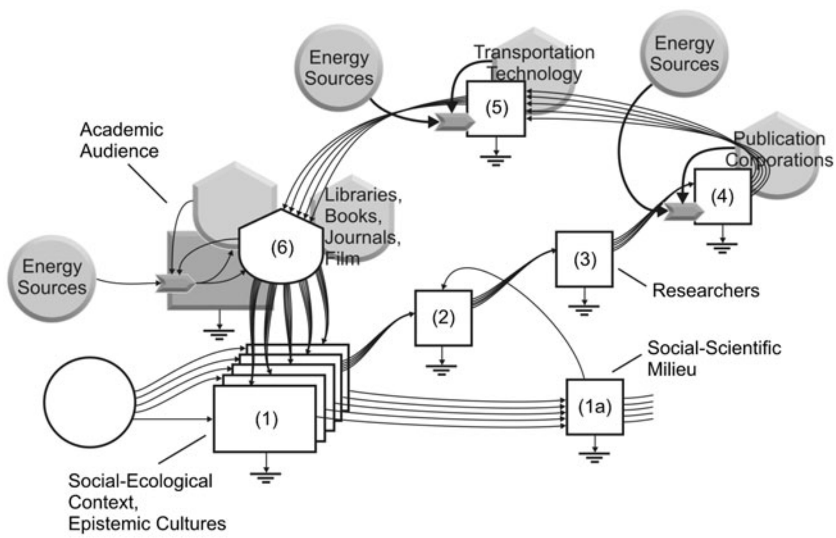

Figure 4. Information in science and academic research. The academic research cycle is relatively slow. Researchers (3) take years to build on the work of others, which has itself been selected by the social-scientific milieu (1a & 2). Today, the great academic publishing houses add energy and technology into the production of academic scholarship (4). Books and journals are physically dispersed around the world (5), where again it may take years for other academics to gain access and to appreciate the results, and to then choose to build upon those results (3). Additional energy inputs are in libraries and today in electronic repositories (6).

technologies for the storage and retrieval of academic publications (added storage, 6). From that location, the publications may be read and the information is then shared by the reader. Academic information then contributes, among other sources, to the larger scaled system, though not often with the force or control that many academics or progressive activists might wish.

As books or papers are shared and read, they affect their social-ecological context. A book that is widely shared may be singled out or selected by the larger scale social-scientific milieu, which includes academics as well as others. Over time, a new round of scholars (and journalists, engineers, or the lay public) may extract some ideas from the work. Those ideas are then incorporated in new research, preserved, and elaborated. The original author may also elaborate their earlier ideas. The book from that author may be preserved as a whole (most common with literary works). In that case, new editions are produced, copied, and dispersed again. The relatively long turnover time of books facilitates the cycle. The effect of new ideas within the system, their degree of sharedness, their selection, and their extraction by future researchers is the focus of the cycle.

Will an idea or technique be copied and used again? This is the question of interest, or it should be, to those who critique science, the conventions of research sites, and the conduct of academics. The production of any single idea, in any single lab, etc. is ultimately diminished when science is viewed as a scale of information cycling. Whether an idea or method is picked up and widely shared is a decadal process or longer, and is the outcome of community choice.

The turnover time of this cycle is perhaps 5–15 years. That rather long duration reflects the time required for research, dispersal, wide sharing, selection by the system and larger scale, and eventual extraction by a new round of researchers. This long duration allows for complex ideas to be produced, transmitted, and understood. As with other cycles, when new energy is applied the speed of cycling may increase.

The cultural information of academic or journalism cycles is not to be found in abstract thought or idea. All information requires a carrier, whether it is electromagnetic wave, paper, music CD, or a human. In most social theorizing, the carrier is omitted or ignored and only the meaning of a message is considered. Among some cultural evolutionists, only the human-embodied information undergoes selection and so is of interest. I am arguing that carriers take many forms, each with its own cycle for selection and distinct turnover time.

5.3. Discourse

The information cycle has now been introduced with these first two scales of cultural production. I will subsequently move more methodically from the small to the large. Human knowledge (Figure 2) in each of us must be maintained (and constructed) as all information, in information cycles. As stated above, the construction of the hierarchy of human knowledge is a lifelong process of building and testing, negotiation, and construction. As we use knowledge in speech (both inner and spoken) and as we interact with others, we are continuously constructing and maintaining knowledge in memory. As all information, knowledge in memory will be lost without use, without testing, selection, extraction, copying, and dispersal. In the examples above, these steps occurred, in part at least, external to human 'carriers,' utilizing various intermediate carriers, such as electromagnetic wave and paper. But, cultural knowledge is ultimately the product of humans, and is at some time carried by human memory. Much, but not all, of cultural knowledge is conveyed with language. I now turn to the role of speech and discourse in the production and maintenance of shared cultural knowledge in human memory, the smallest of the multiple scales of cultural production.

Interpersonal interaction is often thought of as the source of cultural production, or at least of the information that some label culture. Social theories of interaction, face-to-face communication, discourse, etc. encompass a range of related programs of some longevity. G. H. Mead, phenomenology, symbolic interactionism, role theory, the dramaturgy of Erving Goffman, theories of emotion in social interaction, practice theory of Bourdieu, Gidden's structuration, discourse from Foucault, and others share at least a focus on persons engaged in talk, evaluating selves and others, employing various knowledges with some degree of agency (Turner 1998). The information cycle can offer some new insights (Figure 5). The system (1) is the site of the interaction order, encounters, rituals (Goffman 1959), emotion work (Hochschild 1979), interaction rituals (Collins 1993), structuration (Giddens 1984), or fields (Bourdieu 1977). The intersubjective, shared information (6) is the mutual understanding that the self, the agent, brings with them to an interaction, variously, stock(s) of knowledge (Schutz 1967), rules of front (Goffman 1959), feeling rules (Hochschild 1979), cultural models (Holland and Quinn 1987), rules and routines (Giddens 1984), habitus (Bourdieu 1977), or, more generically, ideas, beliefs, roles, and identities (see also Figure 2, Scale 2).

Actors are motivated to participate in interactions by

> needs to confirm self, to realize appropriate resources, to feel a part of a flow of interaction, to believe that others are experiencing the situation in the same way, and to perceive that others can be counted on to believe in predictable ways. (Turner 1998, 447)

Performance is always judged or monitored both by self and by other participants in an interaction (1a). Role-taking performance can be better or worse, as when one causes a 'scene,'

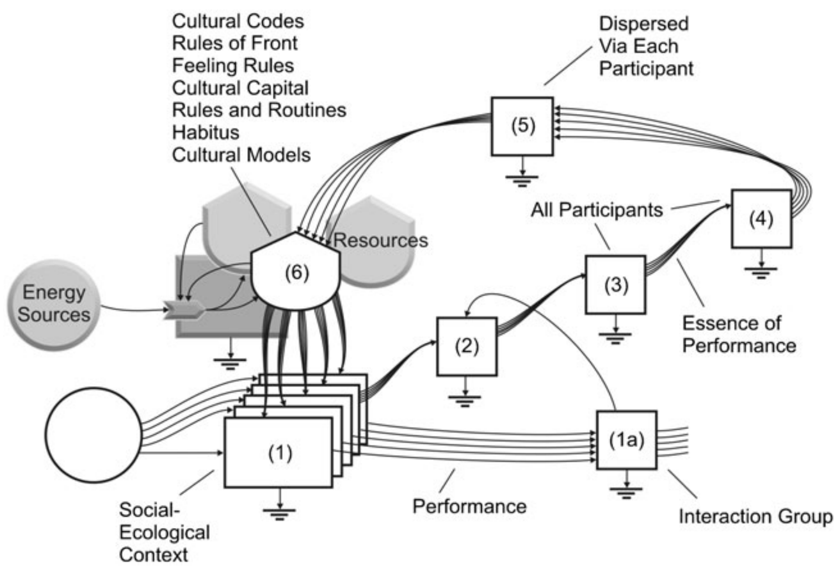

Figure 5. Information in interpersonal interactions. Interpersonal interactions are the charged sites of discourse production (1). Participants bring their own models, codes, or rules of the world and extract the essences of valued performances within the group dynamic (3). They then disperse into the world until their next interaction (5), bearing subjective copies of performance information. Through repeated cycling, these loop models are continuously constructed and reconstructed (6).

'when a person emits gestures that contradict normative roles, presents a contradictory front, fails to enact appropriate rituals, sees an inappropriate role, attempts an incorrect line, or presents wrong face (Turner 1998, 402).' Both agents and participants, therefore, select (2) better performance, extracting (3) a subjectively defined essence of the performance, and as socially learned, make rough copies (4) of that information in the form of individual memories of some/all participants, and, as individuals, disperse (5) until their next encounter with same or other individuals. That information is now lived (6 & 1) by the various participants.

With each of many conversations in a day this cycle repeats, continuously constructing and reconstructing our cultural knowledge, including declarative knowledge but also the implicit rules and resources that we bring to each encounter. This iterative, day-after-day cycling leads to statistical learning, in which threads of shared understanding are gradually negotiated or co-constructed between family members, peers, colleagues, strangers, friends, and enemies.

The fidelity of individual-to-individual transmission of information is obviously of interest in this cycle (Dawkins 1993; Richerson and Boyd 2005). For the cognitive psychologists (Atran 2001; Sperber 1996), it is claimed that transmission is the exceptional case, and significant transformation is the norm in communication. While this may be an issue for memeticists or cultural evolutionists concerned with constructing precise lineages of transmission, the information cycle instead draws our attention to the practical significance of the information at some scale of social-ecological self-organization. Any useful information is the product of perpetual cycling, not a single essence that can be easily lost or corrupted. It is shared and retested with each cycle, and is thus self-correcting and refining. As language learning demonstrates, we possess powerful learning mechanisms that capitalize on the statistical properties of environments (Saffran 2003). Furthermore, what we 'learn' from each interaction is not only explicit content but simultaneously form, ritual, affect, grammar, and model, implicit rules and resources that we bring to each encounter (Figure 2). If it is of value at some scale, information will be cycled again in some form. Additionally, cycling of useful information may be further captured by other scales of information cycling (discussed below).

For some theorists (Bourdieu 1977; Foucault 1980), this statistical learning or selection process (2) takes the form of struggle between participants to impose particular ways of seeing a field or discursive formation. The result is better characterized as a diversity of shared information(s), discourses, and cultural and symbolic capital, which constitute power and class differences. But, that diversity is not infinite. Rather, it coalesces as various pools of shared understanding. The information cycle of interpersonal interaction may be indeed a location of struggle and symbolic violence. But, its form again is one of selection and learning. And each cycle is arguably located within the directionality of self-organization. 'Fields' do not form anywhere, for example (Bourdieu 1977); they are the products of recursive interaction/learning within social-ecological contexts. Their form is arguably channeled by limits, needs, and efficiencies of the complex context of their nesting.

5.4. The internet and social media

If discourse is exceptional for its pervasiveness, its rapid cycle time, its low-fidelity but statistical nature, and its small spatial scale, a new form of cultural production has recently emerged that shares a number of the features of discourse. The internet has permitted the proliferation of new communication modes – email, Facebook, wikis, game worlds, twitter, instant messaging, texting, and blogging – which together have been termed social media

(Kaplan and Haenlein 2010). How do social media differ from regular discourse, how are they similar, and how can they be represented within information cycles?

In contrast to science, news media, and other scales of cultural production that will be discussed shortly, social media, like conversation, is pervasive, fairly rapid to produce, and relatively small in spatial scale. However, like the other forms, but unlike conversation, social media allows time for composition and editing of messages, the first step toward improving copying fidelity. Additionally, social media requires advanced technologies and energies in copying and dispersal. Furthermore, while some media are targeted to individuals (email, texting, instant messaging), others are broadcast to a broader, largely anonymous audience than regular conversation (Twitter, Facebook, wikis, blogging). While audience size is commonly larger than conversation, it is smaller than news media or science. While cycle time is faster than other electronic forms, it is slower than conversation. While the number of acts of production in some days for some individuals may be substantial, conversation remains the most pervasive act of culture construction across society. While conversation requires the physical aggregation of individuals, social media's single greatest efficiency is that it permits 'conversation' without requiring human congregation. But as just clarified, social media is not 'conversation,' but is rather a distinct scale of cultural construction, clearly differentiated by its required inputs, cycle time and space, the fidelity of intermediate carriers, production counts, and arguably the impact that it can deliver, as it can be reread, studied, and carefully responded to, unlike conversation.

In the information cycle (Figure 6), as we respond to or initiate topics of discussion, social media content is produced or extracted (3) by you and I from its cyberspace context, nested within its larger social-ecological context. However, as in science or the news media, content is selected (2) by the larger scale conventions of the media, and as in conversation, by the conscious and unconscious shared understandings of the interaction group. The next

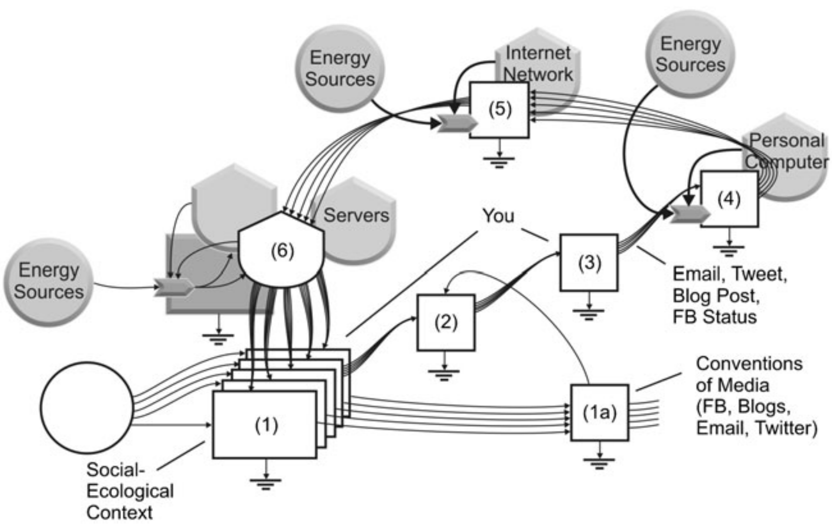

Figure 6. Information in internet social media. Social media utilizes new and evolving technologies to produce the most rapid scale of information cycling after discourse. Essential technologies ('sources' and 'storages' added) include personal computers or phones and access to internet networks and server storages. Sometimes referred to as new styles of conversation, social media is actually dramatically different on all the definitive scale characteristics (see text).

three steps, copy (4), dispersal (5) and storage (6), require the advanced technologies of electronic communication and the energies (electricity, satellite transmission, etc) that support it ('sources' and 'storages' added). As a message is produced and dispersed, it enters internet cyberspace and the larger social-ecological context. Here, it may or may not initiate additional cycling within social media. Finally, as interest in a topic fades, the interlocutors themselves disperse (5) into their larger contexts (6 & 1) where topics may be picked up by larger scales, or contribute to our everyday conversations at the smaller scale of discourse.

To reiterate, social media is not conversation, or a mode of conversation. It is a uniquely different scale of communication and cultural construction, with definitive qualities that are empirically distinct, e.g. cycle time and space, which locate social media (on average) somewhere between discourse and news media in the hierarchy of cultural production.

5.5. Ritual

Ritual is pervasive in human sociality cross-culturally (Figure 7). Many of the information cycles discussed in this paper are the products of complex civilizations (education, science, legal codes) and/or advances in technology (printed and electronic media). Ritual, on the other hand, represents the most universal and ancient form of repetitive and broad information sharing. It takes many forms, but can be recognized by its relatively consistent structure through time, and its use of symbols. Whether church service, college football game, or Ndembu puberty rites, ritual requires planning by experienced organizers who formally or informally select (2) the best elements of past performances in reproducing the desired ritual effect. All participants (e.g. adults and 'novices' in a puberty ritual) extract (3) the essence of the performance, whether explicit knowledge or the emotional arousal of group solidarity

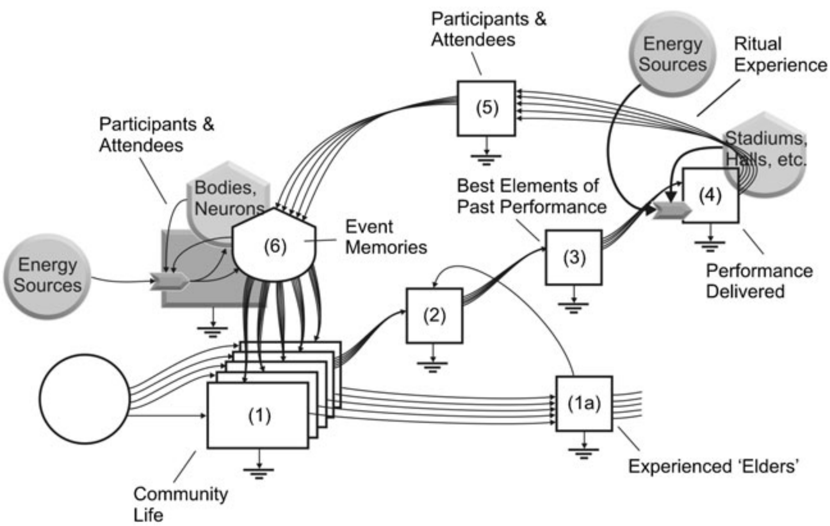

Figure 7. Information in ritual. Rituals of many kinds can be represented by this cycle. 'Elders' of rural societies or capitalist states can select (1a & 2) the best elements of past rituals (3) to construct new performances which are performed (broadcast, copied) (4), often in the confines of ritual arenas or stadiums. As in interpersonal interactions (above) and education (below), the participants disperse (5), each possessing some essence of the performance. They then live their lives (6), wherein the performance information may have some effect, including selection for a new round of ritual (2).

(Collins 1993; Durkheim [1915] 1965). As in interpersonal interactions, above, the performance information is thus copied (4) in each individual's experience (which may require great halls or stadiums, storage added), and those participants at the ritual's conclusion then disperse again (5) into their daily lives (6).

Rituals often combine narrative and performance. Narratives may be loosely or tightly scripted. The turnover time of ritual should include the ritual preparation, which may be days, weeks, or longer. This places ritual intermediate to news media and the next topic, formal education.

5.6. *Formal education*

One of the most important components of enculturation in most societies today is our formal education experience. Classroom encounters are composed of interpersonal interactions of students with teachers and course materials. In Figure 8, teachers extract and process information, prepare course plans, produce materials, and ready lectures (3). But as with media and science (above), subject, subject matter, and often textbooks are selected (2) for teachers by a larger scale that includes elites of education, academia, and ultimately the political-economy (1a). Within that context, teachers prepare their courses. Course materials are copied, some via publication technologies in the case of textbooks or workbooks, and as lectures that are delivered (broadcast, i.e. copied) (4). This information is dispersed (5) as the students themselves disperse, allowing them to operate within their many worlds (6).

While composed of interpersonal interactions, the turnover time of this cycle is better seen as the length of a course. While teachers may daily sense the effectiveness of their own teaching, and modify their course materials, a larger process of selection involves the grading of students and evaluation of the class by principals and other elites (1a). Such evaluations generally come at the end of a course.

Formal education gains its force to enculturate through its highly structured and repeated daily interactions. Components of the formal education process that make it effective include

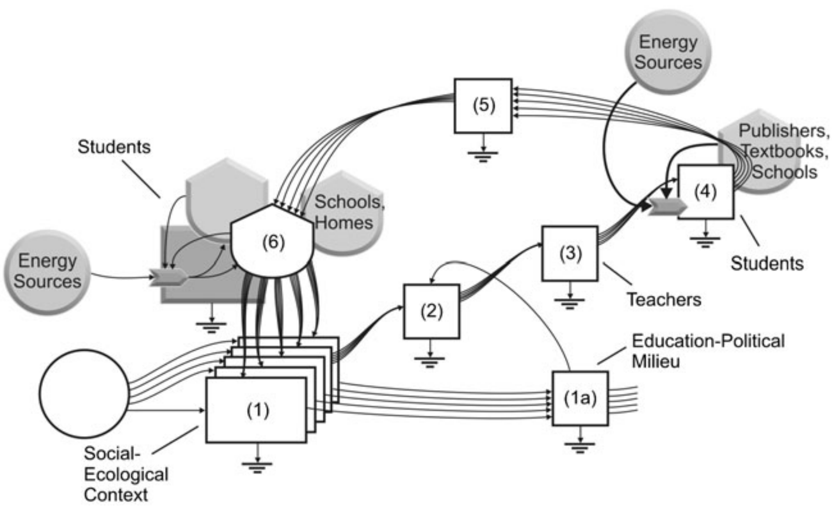

Figure 8. Information in formal education. Teachers construct courses from within an education-political milieu (1, 2 & 3). Course information is broadcast in lectures and books to students who subjectively absorb it (4). Students then disperse into the world with that information (5). Various forms of feedback from students and society determine whether a course will result in future similar courses.

repetition and review, structured content, presentation by engaged instructors, and an active, motivated learner (Woolfolk 2001, 282, 485, 496, 377). Formal education is composed of daily learning interactions, as described above, but in addition, by its prolonged and structured character, it offers opportunity for learning complex concepts and skills. Of course, formal education is also part of the existing capitalist production structure, and many well-learned themes about competition, social hierarchy, and ranking contribute to the perpetuation of that context.

5.7. Legal codes

The rules of capitalism are encoded in law – contract law, property law, corporate law, commercial law, succession law, insurance law, labor law, intellectual property law, tax law, securities law, banking law, maritime law, and even much of tort law. An inquiry into the information that sustains the current global economic system leads us to law, although many other (all?) information cycles have been structured by and contribute to the capitalist system, including especially technology (next) and even discourse (i.e. in the production of social and cultural capital, etc., discussed above). The maintenance of the legal codes associated with the global economic system is essential to that system. But because there is a range of turn-over times, and some are very slow, it is difficult to sense the cycling of the body of legal information. At the slowest scale, national constitutional codes are 'sacred' documents of great age, literally carved in stone, or clay tablets, or written on hermetically sealed parchment, and they appear to be nearly unchanging (e.g. the US Constitution, the Code of Hamurabi, or the Tang Code of ancient China), but of course they do change perhaps after generation's of struggle, or more abruptly as states come and go. Other law, such as the public statutory law of the USA, called simply the US Code, is more regularly undergoing cycling of its parts. Much of US common law, or private law, especially that associated with business, is even more frequently applied in the courts and thus cycled.

In lesser courts, when a private law or precedent is invoked in a court decision, that decision is recorded, copied, and dispersed throughout that jurisdiction. If a decision is appealed and heard by a higher court, that decision is dispersed even more widely. If the highest court in a country, the US Supreme Court for example, hears a case, its decision becomes the law of the land and is shared most widely. In this process (Figure 9), one by one, the essence of legal rules are extracted (3) and applied and sometimes modified and copied (4), and the ruling is dispersed (5) again (energies added), where it is lived in the larger social-ecological system (6&1), providing rules for business and other behavior. The selection (2) of which laws will be exercised is of course the product of the punitive-legal system itself, but it is also a product of the larger context of the economic production hierarchy and its related social hierarchy (1a).

The contemporary anthropology of law (Moore 2005) has taken many different directions, but adds the significant recognition that law in past and present conditions has never been static, frozen in custom,

> No longer is the law of a people seen as a seemless part of their tradition-in-practice, their social values and customary actions of long standing … The law is seen as something being made, as an entity in process, as something developing in historical time. (Moore 2005, 176)

My demonstration is with the dynamics of legal processes in contemporary Western states, and does not address past conditions or the emergence of legal institutions. And yet in that abbreviated space and time, change, construction, contestation, and critique characterize

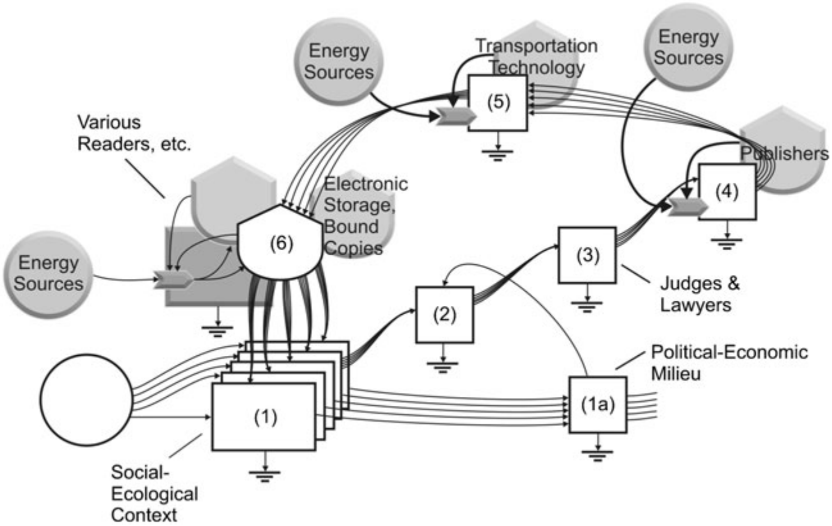

Figure 9. Information in legal codes. Laws in some form are invoked upon selected behavior (2). Judges and lawyers extract the essence of laws (3) in decisions that are then copied (4) and shared widely (5), constituting precedence or amendment, depending on the type of law. Legal decisions are returned to the larger social-ecological context (6&1), where they may again be tested, challenged, and invoked, or where they may influence other information cycles.

legal codes and legal practice. An information cycle of law captures that dynamic, as it does for other information forms.

5.8. Technologies

This last cycle to be discussed is different from the others. Odum at times characterized information instrumentally. Information can be understood as 'something that requires fewer resources to save and copy than to make anew' (Odum 1996, 221). It could exist in extracted form, such as DNA or a road map, or it could be embodied in an object, like a hammer, or in a configuration of objects, like an ecosystem or a corporate organization. A hammer is an example of a technology. In our human history, we have produced technologies both with and without extracted 'plans,' 'wiring diagrams,' etc. In either case, the information cycle applies.

We can imagine a hammer or maybe a primitive axe or digging stick in use by a farmer on a swidden plot (6) (Figure 10). The farmer happens upon a new binding material (by accident or intention, either will do for this demonstration) to attach the stone axe blade to the handle. After some use, she and other farmers recognize the value of her modification. The farmers then select (2) the essence of the axe from the tool in use, extracting (3) the information in the configuration, producing new copies (4), and dispersing (5) them to neighboring farms (6).

Alternatively, a chemist in the early years of the last century experimenting with synthetic resins would discover a hard material that could hold its shape when heated, the first plastic (Bijker 1987). After success in the laboratory, the chemist extracts (3) the chemical formula and manufacturing techniques from memory into written form, much like reproduction extracts DNA into fertilized seed or egg. Many copies are made (4) and dispersed widely (5)

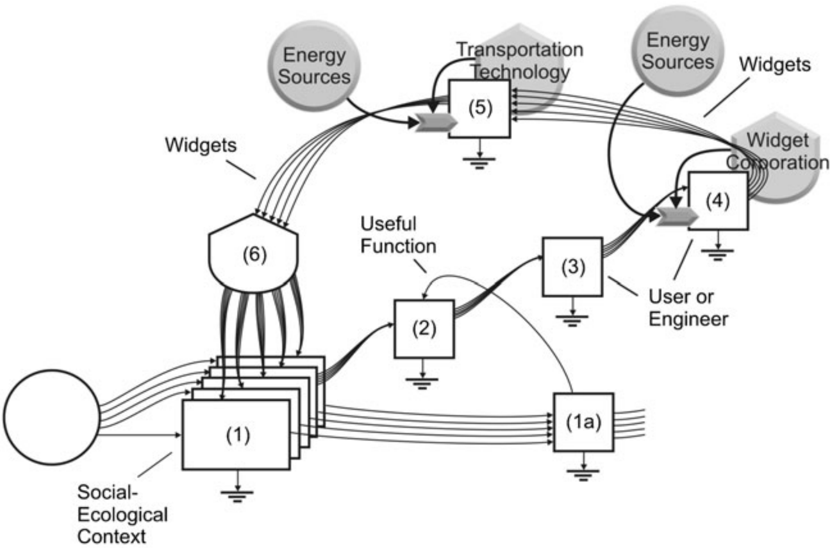

Figure 10. Information in technologies. Useful function is recognized in many ways (2), most simply by profit, but many other currencies might signal value (1a). Users extract the essence of a technology (3), sometimes as plans or maps. Communities or corporations produce copies of the new widget, often by adding substantial energies and materials (4). The new widgets are now dispersed (5) with their users/owners, sometimes after adding the energies of transportation and retail sales. The new widgets then live their productive lives, sometimes lasting hundreds of years (6). Their value may again be recognized and copied in a new cycle.

via reporting, e.g. to the American Chemical Society in 1909. The invention is then exposed to the wider world (1&1a), where indeed it was picked up again (2) and new applications realized. The mindboggling diversity of novel uses for plastic was unimagined by its inventor. Repeated cycling over 100 years has given us the proliferation of uses of plastics that we observe today.

Critics and ethnographers of science and technology have emphasized the chance nature of many innovations and their often ambiguous initial potential to affect an industry, practice, or society. According to Woolgar, for many STS researchers, the capacity of any new technology is continually renegotiated within a larger political-economic context; 'design and development are not straightforward extrapolations from existing technical knowledge and options. Instead, the technology is to be understood as the contingent outcome of a series of social, political, and organizational factors (Woolgar 2005).' This captures precisely the effect of the continual cycling of technological information and products within information cycles. Technologies are not neutral to their social and political context, and their acceptance and wide dispersal is often not 'obvious' or 'natural' at the time of their appearance. Technologies, rather, are continually evaluated in the sometimes halting and diverging process of becoming established through cycles of use in the larger world. As in the production of any form of information, its (shiftable) function(s) in a multi-scaled world is what determines its persistence.

The cycling time of the technology information cycle cannot be generalized because technologies are so varied and have so many different turnover times. Dams or bridges can last hundreds of years, while cell phones only three. Somewhere in that lifetime, a valuable change may be picked up and copied.

5.9. *Other forms of cultural information*

As stated before, I want to acknowledge directly that this is not an inclusive list of information forms. A number of important omissions that immediately come to mind are the information produced (1) by the market, (2) the visual arts, and (3) movie and TV entertainment. Perhaps, especially relevant today is the information produced by the stock market with its rapid turnover, and the information in corporate annual reports produced by large financial institutions, which has a slower turnover and many inputs. Other forms of cultural information can be proposed. It is recognized also that each of these forms may themselves be differentiated into a nested hierarchy of forms. This was seen in the diversity of technologies, in the variety of social medias, and in the US legal system, an indisputably hierarchical system of high courts and low.

6. Intellectual siblings

Evolutionary anthropology presents perhaps the closest comparison to the concerns of this paper. Issues of 'cultural transmission,' 'social learning,' transmission 'fidelity,' and others have emerged as important components of various schools of Darwinian cultural evolution. I will briefly consider a sample of this work in an effort to mark important differences with my position.

In one widely known evolutionary approach, cultural traits, called memes, are spread like a virus, infecting minds with ideas (Dawkins 1993). In that case, a successful trait should have the characteristics of longevity (living long and thus infecting more minds), fecundity (rapid copying and thus spreading), and copying-fidelity (accurate or faithful copying) (Heylighen and Chielens 2009). Support for this memetic approach has been dwindling (Aunger 2000, 2); nevertheless I will discuss it briefly, since it may appear superficially to be related to the approach of this paper. From the perspective of this paper, problems arise with each of these features. But first, more generally, unlike a virus, I contend that there is no significant information drive; the persistence of information is related to its function(s) in the multiple scales of the biosphere. I contend that longevity is related to information carrier, which itself is related to the place of information in a hierarchy of information forms and their related quality (below). Fecundity is another mistaken goal; speed of turnover is related again to information carrier, which is related to the hierarchical position of information. And finally, the goal of fidelity is mistaken because it denies, or attempts to resist, the fact of Second Law depreciation and its role in generating variation. At certain scales of information reproduction, fidelity is of greater importance and carrier turnover times increase, but again, that is related to the function of information, not to the maintenance of viral strength.

In a competing evolutionary approach, it is proposed that a second line of cultural inheritance exists parallel to the genetic line of inheritance, and thus 'dual inheritance' describes the human condition (Henrich and McElreath 2007; Richerson and Boyd 2005). Applying theory and method from population genetics has led to a number of interesting and provocative claims. Perhaps surprisingly, the focus of this research is not the selection of information, but the selection of individuals bearing cultural information and, through those selected, the transmission of traits to next generations. This process is an analogue of biological evolution that focuses on lifecycles and genetic information, in which individual genetic traits are not selected, but rather are whole organisms. The difference is that in cultural evolution, children can acquire cultural information from parents and additionally from nonparent others. The information cycle applies both to this scale of human-embodied information in reproduction and to other scales of information in which the carrier is not only the minds of people. The first case is well known, and requires only minor deviations from the genetic model of information cycling (Figure 1) (e.g. biased transmission), but as the many other scales of information cycling have never been identified and elaborated, they have been the focus of this paper.

7. Anthropology, energy, and information

Anthropology has thus far ignored the Second Law nature of culture (of the universe generally, though see Adams (1988)). As I have explained, the universe possesses a fundamental arrow in time – a directionality – from concentration to dispersal, from order to disorder. Information is especially prone to degradation, due to the fragility of information carriers, like DNA, paper, sound waves, electricity, and human minds (as they age, forget, etc.). By ignoring degradation, we are simultaneously devaluing function; that is, the value of information to the process of self-organization, i.e. what cultural information does.

Among the cultural evolutionists, mutation, a form of depreciation, is of course recognized. Mutation is a fundamental component of evolution, and the population genetic models that are today applied to describing cultural evolution inevitably incorporate both mutation and selection in their formulations. But their emphasis, and the emphasis of evolutionary biology, is understandably on the traits (cultural variants) that survive the process, that are indeed selected. This is the trajectory that we observe when we study either the fossil record or (pre)history. Once a trait or new species is established, the focus then becomes the next adaptive change or speciation, not the work required to maintain the existing suite of traits, the work of eliminating defective copies, which customarily, in evolutionary theory, goes without saying. We are occupied by the successes, not the aborted or chagrined.

The information cycle, with its explicit incorporation of Second Law Thermodynamics, emphasizes the fact that cultural information is continually lost or degraded as instances or 'copies' of information dissipate. Thus, the process of eliminating error – of maintaining useful information – deserves emphasis. Cultural information is not created once and for all time. It is perpetually 'reproduced' and 'tested' in an ongoing and essential process that maintains function on multiple scales.

8. Reassessing the information cycle

Each of the cycles of information production described above can be explored independently, and that work is underway (Abel 2013). But addressing each together has led to innumerable revisions and realizations, each pressuring and informing the logics of the others, without which a weaker argument would have emerged. I will now reassess Odum's information cycle in light of the issues raised here. I will do so within the context of complex systems science, but particularly within the vast theoretical program created by H. T. Odum, and in particular his Fourth and Fifth energy laws (for those interested in the mathematical derivations of Odum's energy laws see Giannantoni 2002). I will not attempt to validate or confirm his many related arguments, but I will use them in lieu of other programs within complex systems science because of the natural fit to the arguments made here about information. It would be, in fact, a most interesting exercise to apply the insights of this paper to some of the other related theoretical projects, such as the resilience program of Holling and colleagues with their explorations of discontinuities in nature (Allen and Holling 2008). Such an integration, however, would be a considerable effort and must await another occasion or other researchers.

8.1. Function

Information is a phenomenon that has function in directional systems of energy use and dissipation. It maintains self-organization through time and space. It thus has consequences that can be better or worse, and so the value of selection. This simple pattern is found in biological evolution, cultural evolution, and learning because, in this general systems model, each functions to improve the scope and efficiency of self-organization. The construction and maintenance of cultural information is one more directional and functional learning process.

Consider again the typhoon from section three above. Individual water droplets are unaware of the typhoon structure of which they are a part. There is no intentionality in their part of the typhoon's formation, and yet there is function in the reduction of a summertime energy gradient. In contrast, there is certainly intentionality in the production of cultural information. And yet, in its most common form of everyday discourse, information production is rapid and voluminous. Contestation, negotiation, and selection are incessant processes in cycling that has no end. The result, as in the typhoon, is pattern that is functional – functional, it is argued here, in the same way that is a typhoon. An important difference is that the energy gradient structure within which cultural information (and life) is produced is far more complex than the simple hot-to-cold gradient of the atmosphere. It is multi-scaled, with semi-autonomous processes at each scale of our complex social-ecological context.

8.2. Maximum empower

And thus second, from a systems perspective, the function of an information cycle is in the contribution it makes to maximizing the self-reinforcing flow of energy (maximum empower), Odum's Fourth Law of Thermodynamics (Odum 1996). What I have suggested is that each of the cycles contributes. The many information cycles occur in parallel with one another, ever interacting and always self-organizing with the larger-scale biosphere. No information cycle is independent of the others, and all are structured by nature's thermodynamic arrow in time.

8.3. Scale and hierarchy

But third, these information cycles differ from one another in energy and material inputs, which fundamentally characterize each form of information. In addition, they differ in cycle time and in space, which taken together is often referred to as scale. It may be that the contention in anthropology regarding 'culture' reflects the fact that cultural information is complex, composing precisely the structure that systems scientists would expect, which is a hierarchy (Allen and Starr 1982; Gunderson and Holling 2002; Odum 1996, 24). As cycles at different scales, they can be arranged in a hierarchy, as in Figure 11, from left to right in increasing dimensions of time and space.

In this form, we can see, once again, a common pattern in nature that Odum calls an energy transformation hierarchy, his proposed Fifth Law of Thermodynamics (Odum 1996, 16). Here, many events of shorter duration on the left contribute to fewer and longer events as one moves to the right. In energy transformation hierarchies, as energy is converged (moving to the right), there are larger and fewer objects, which have longer turnover times, larger spatial scale, higher search/exploration ability, higher maintenance cost, can take more varied inputs and/or from varied sources, and have larger feedback effects (Odum 1996, 24). Each of these properties is found in the information hierarchy.

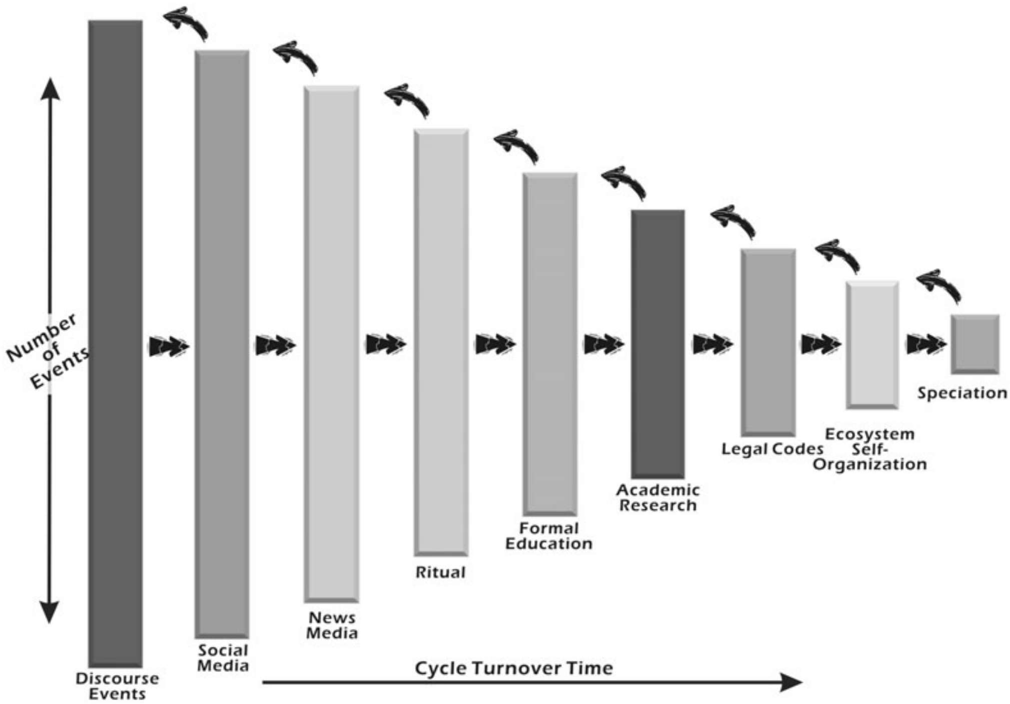

Figure 11. Information hierarchy. These 'process' boxes are intended to represent each of the different information cycles, with the size of objects depicting the number of cycle events. For example, many discourse events occur each day for any person. These may generate a few topics that are picked up by the news media, or contribute to the production of some ritual. With each scale, there is also feedback. Social media may contribute to the production of news stories, but those stories may feed back to influence blogging, texting, or spoken discourse. At the other end of the hierarchy, speciation is a product of repeated rounds of ecosystem reorganization with adaptation, while obviously speciation when it occurs feeds back to succession by providing new material for self-assembly. In this diagram, both axes are approximate log scale (Figure 12).

Estimated turnover times from the text are graphed in Figure 12. Note that they are approximate orders of magnitude apart, a common pattern in energy transformation hierarchies.

Perhaps of special interest to evolutionary anthropologists is the fact that cultural information at each of the scales differs in systematic ways related to copying fidelity (next) and to the vertical sharing or upgrading of information (below).

8.4. Copying fidelity

The fidelity of the copying processes in these cycles, especially at the scale of discourse, is of great interest to some cultural evolutionists and cognitive scientists as stated above (Atran (2001), Sperber (1996), but see Henrich, Boyd, and Richerson (2008) and Claidiere and Sperber (2007)). From the perspective of this paper, copy fidelity is related to Table 1, and, in general, it can be said that it increases with scale. Copy fidelity at the small scales is indeed relatively inaccurate. This may relate to both cognitive architecture and to the maturation process of human culture bearers. But in addition, at all scales, it is related to the

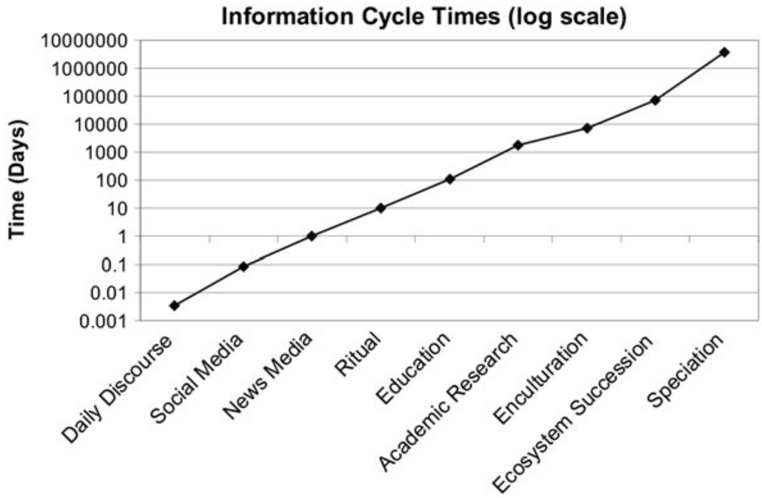

Figure 12. Information cycle times (log scale). These are estimated cycle times for information: discourse events (5 min), social media (1 h), news media (1 day), ritual (10 days), education (16 weeks), academic research (5 years), legal codes (20 years), ecosystem succession (200 years), and speciation (10,000 years). These cycle times are each an approximate order of magnitude apart. Thus, on a log scale, they form a nearly straight line. This is a common pattern of self-organized systems, expected by Odum's theory of hierarchy. Other cycles may be argued to exist and should be included.

Table 1. Copy fidelity. Each information cycle utilizes intermediate information 'carriers,' such as paper or electromagnetic waves. This, and other factors, determines the fidelity of information transformation, which increases with scale (moving down the rows).

Information cycle	Intermediate cycle carriers
Discourse event	Sound waves
Social media	Hard drive, electromagnetic waves
News media	Paper, electromagnetic waves
Ritual	Program, amplified speech, performance
Formal education	Speech, paper, textbooks, published standards
Academic research	Paper, libraries, library copies, electronic storage
Law & business	Paper, bound copies, libraries, repositories, electronic storage
Genetic information	Seeds, eggs
Technology	Paper, object, electronic storage

intermediate information carriers within any cycle. As information at each scale returns to the complex social-ecological system, it is assimilated into individuals and individual memories. But within each cycle, various other carriers will improve the fidelity of information transmission at each increasing scale. Table 1 lists some of the intermediate information carriers.

Obviously sealed repositories of finely bound paper copies of legal codes spread around a country provide a secure source for future extracting and copying. Ancient legal codes carved in stone are even more durable, though not shared as widely. At the other end of the hierarchy, regular speech or social performance will lead to transmission errors for psychological and other reasons. But, this is not an objection. At all scales, fidelity is not the point – it is function. At larger scales, function is enhanced by fidelity, but at smaller scales, with rapid cycle times, corrections and improvements are constantly made, resulting in functional consistency, but not fidelity per se. This consistency may include the work of psychological attractors (Sperber 1996), or it may include the biasing for prestige or conformity (Richerson and Boyd 2005). These considerations sharpen the picture, but they are still insufficient. Cultural transmission does not only occur between individuals and through speech, and function that contributes to self-organization does not only apply to individuals or individual fitness. Cultural information at all scales contributes to ecological, economic, and human organizational processes. At small temporal scales, transmission is enhanced by rapid turnover, learning is statistical, and outcome is expected to result in practical knowledge for some process of our social-ecological context. For cultural information that is pushed up to larger scales of space and time, fidelity contributes to the sharing of highly instrumental information.

8.5. *Vertical sharing*

Cultural information may indeed be picked up by larger (and smaller) scales. The hierarchy of Figure 11 is thus more accurately depicted as a nested set of information cycles, each connected to the same complex social-ecological context of human existence and cultural production (Figure 13). And so, for example, regular discourse that is captured and upgraded through the popular media is widely dispersed, new energies are applied, and the information will have a longer turnover time than most conversation topics. Information that is further picked up by ritual, education, research, or law has progressively larger dispersal and longer turnover time. Thus, we see the function of the upgrading of information within a hierarchy of information scales. Information that is pushed up to higher information scales requires additional energy for its (re)production and maintenance, for which is returned greater fidelity, wider sharing, and longer turnover times.

8.6. *Information quality*

Each of the products in Figure 13 differs in its complexity of production, inputs, cycle time, space, fidelity, and its ability to feedback and structure information and the human-ecosystem at smaller scales. Again, the function of feedback is to reinforce the intake of energy at its optimum efficiency. Taken together, these characteristics are referred to as energy quality (Odum 1996, 26). In Figures 11 and 13, quality increases from left to right.

8.7. *Cause and consequence*

It is Odum's thesis that all scales in a complex system such as the earth's biosphere are structured or entrained by energy self-organization. Unlike most social analogues of the modern evolutionary synthesis, explanation here does not radiate (only) from natural selection of individual members. Instead, an alternative 'consequence law' for an acceptable functional explanation (Smith and Winterhalder 1992) is Odum's Fourth Law, maximum empower. A consequence law is one that shields functional arguments from the most common critiques of functionalism by providing an underlying causal mechanism. Natural selection is such a causal mechanism (via the random generation of variation) that leads to fitness or adaptation. Self-organization (maximum empower) is another causal mechanism that arguably structures physical systems, ecosystems, and human cultural systems, and which can underlie social-functional arguments that relate to the use and organization of energy and materials by people armed with symbolic culture. And so, what we should expect to find is system self-organization that over time taps all available energy sources and storages and produces the best

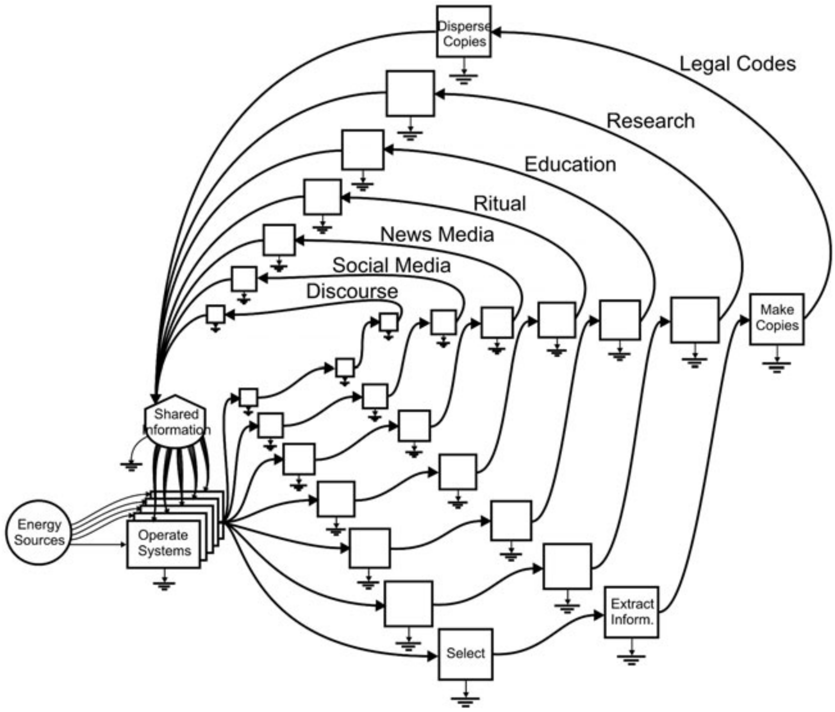

Figure 13. Hierarchy of information cycles. This figure represents the hierarchy of Figure 11 as a nested hierarchy of information cycles. The value of doing so is to accentuate the fact that each returns objects of information to the same social-ecological context, from which any information may be picked up by any cycle. By moving out to larger scales, new energies are applied, information may be shared more widely, and its turnover time is increased. The fate of any piece of information is highly contingent and unknowable, but we should expect that information that is selected will contribute to self-organization at some scale of the social-ecological-informational context.

efficiencies of energy transformations both (1) within each scale and simultaneously (2) in the larger 'system' of the self-organizing biosphere. Evidence of this structuring is being sought within scales of the many information disciplines (Abel 2013), and within the larger human-ecosystem whole (Brown and Ulgiati 2010; Odum 1996).

8.8. Maladaptive information?

And yet, last, a popular – almost universal – argument is that cultural information may be maladaptive for the individual who bares it. Examples are chain letters, dangerous medical 'cures' (Blackmore 1999, 7), religion (Dawkins 2006), reproductive restraint (Richerson and Boyd 2005, 149), or climate change denial (Dunlap and McRight 2010). These behaviors are anomalies of evolutionary logic that require some appended rationalization. How can such behavior exist when it reduces an individual's fitness? But this remains the individualist, bottom-up, single-scale reasoning that has come to permeate the social sciences, and occlude explanations of structural complexity and power, favored by Marxists, for example, or explanations of material and ecological structuring that were favored by the last generation's cultural materialists, reviving perhaps in this generation's niche constructionists

(Fuentes 2004; Schultz 2009). These evolutionary explanations, while part of the answer, are arguably incomplete because of their fragmentary conceptualization of the world and its (single) location of causality. It remains an empirical question (that should be pursued), whether bottom-up can ever reach the top when faced with the complexity of the real world. But many anthropologists, I believe, sense that such explanations may not be sufficient, and regularly produce alternative functional explanations of some complexity in their works, Marxist and others. I am arguing, otherwise again, that social scientists should consider how the social phenomena that they observe can be related to energy self-organization in a multi-scaled social, ecological, and informational world.

9. The information cycle in a postmodern world

Negotiation or contestation within a dynamic and exceedingly complex subjective and external world is a fundamental characteristic of human cultural production, and critical, poststructural, and postmodern social theory has repeatedly made the point (Bourdieu 1977; Foucault 1980; Knorr-Cetina 1999; Woolgar 2005). The information cycle embodies and represents that politically charged contingent context at its many scales of culture formation – thought, discourse, media, ritual, education, market, science, law, etc. Cultural information is perpetually (con)tested in its larger context and selected. Cultural information is not produced once and singly copied through time (so neither is it imposed upon any faction of society). It is lived, and it requires a population of interpreters and carriers, each nested in a material and social world. The information cycle emphatically captures a postmodern, poststructural cultural sensibility.

Obviously, this paper and its exploration of the information cycle is not removed – with a privileged view – from this nexus of cultural information production, but rather is a product of one of these scales of information production – the scientific mode of communication. It is loaded with 'mastercodes' from physics and physical chemistry like the Second Law of Thermodynamics and self-organization (Rosenau 1992). It is a 'logocentric meta-narrative,' grounded in self-constituted logic (e.g. self-organization results from the universal teleomatics of energy dissipation). It is circular, self-referential, and self-satisfying (e.g. due to the Fifth Law Hierarchy Principle we should expect to find hierarchy in social systems and information). Conceiving science as an information cycle makes explicit that science is constrained and constructed within a larger scale of the political-economic context of Western empire, colonialism, and capitalist hegemony. So it is.

While granting that it is one scale among many, however, science possesses characteristics of human and energy inputs, cycle time and space that result in elaborate constructions of knowledge, persistence, accessibility, and political-economic force that distinguish it. While a socially privileged information cycle with a Western history, it is the product of multitudinous cycling and perhaps millions of authors (most unknown, not the cryptic intellectual lineage we are taught in school), which has arguably produced remarkable characterizations of the world, resulting in innumerable new processes and manipulations that effect our lives, and that have come to support a global political-ecology of 7 billion people. These facts cannot be dismissed – or easily reversed. This is not to deny the injustice of the hegemony of Western science and thought more generally. The living legacy of colonialism and the hegemonic structures of modernity have been exposed and challenged by anthropologists for years now. What has in that time been neglected, however, is the instrumentality of capitalism, the force behind the forces of production, the functionality, not only signification, of material practicality, which in our current dilemmas of looming natural limits challenges an effete materialism lacking in material.

Rejecting or abandoning or de-funding the cycle of scientific information production would deprive the world of a powerful force. Leaving information production to the popular media or ritual cycles would invariably require less of society's resources. This may be inevitable to some extent as world energy sources contract. But, the result would be information production that, with the information cycle, we can empirically argue would be of lower quality; that is, it would have less ability to structure and manipulate our human-ecosystems. While this might appeal to some, perhaps many of us, pragmatics suggests caution. In a world of 7 billion people and contracting total energy resources, that information could prove invaluable for a softer landing, or prosperous way down (Odum and Odum 2001).

10. Cycling, cycling

At the temporal scale of human awareness, we commonly do not sense the cycling that is all around us. Some cycling is too fast, some is too slow. At the smaller scales of our daily memories, casual conversation, tweets and status updates, and the news stories we follow, there appears to be little permanence. Indeed, at the daily–weekly scales of time at which we live our lives, such information is ever changing, ever reconstructing. At the larger scales, on the other hand, the pools of cultural information appear relatively static – a population of shared academic ideas, of laws, of education curriculum, a stable population of road design, or a stable population of African elephants. The information cycle allows us to see how each of these information forms is continually cycled at its own cycle time in the maintenance of information against depreciation. The information cycle makes us aware of the cycling at all temporal and spatial scales that is required – is fundamentally necessary – to maintain any information in a directional universe, in a universe that is perpetually loosing structure as it dissipates energy. Culture, in total, is the nested hierarchy of information cycling that provides the continuity and persistence of our unique form of (human-) biosphere self-organization.

11. Conclusions

H.T. Odum proposed a general theory of information, one that spans and connects academic disciplines. Cognition, discourse, media, education, evolution, ritual, law, and culture, these have been productively investigated in the social and natural sciences but in relative isolation one from another. The fourth and second energy laws connect them. Information has function; it maintains self-organized structure in bodies, in memories, in discourse communities, in societies, and in human-ecosystems. But information is easily lost; its carriers are impermanent at every scale. It takes information cycles that repeatedly copy, disperse, use, and select to perpetuate information of all types through time. This is Odum's thesis.

Culture is not a shopping list of traits. Cultural information has been here found to be a hierarchy of information, maintained in distinct information cycles, nested together as other complex system hierarchies, with (semi-) autonomous processes at each scale, yet interacting, and channeled by the directionality of system self-organization. Each form of cultural information represents a different scale of information produced in its own cycle, which compose the hierarchy of information production. For social scientists, therefore, our celebrated, yet sometimes disdained, concept of 'culture' is neither singularity nor trait list, but rather a hierarchy of information at different scales.

This leads to a number of implications for information, and for evolution. Reproductive success of the evolutionary psychologists, for example, is obviously not the only measure of useful information. Information is selected at each scale, per its own 'system' requirements, located within the directionality of system self-organization. The complex human-ecosystem is the location of information formation. A households' social hierarchy self-organizes with an economic production hierarchy, which self-organizes with natural ecosystems and ancient storages of hydrocarbons and metals in the ground. Cultural information functions to organize each hierarchy, maintaining, negotiating, and renegotiating self-reinforcing structure through time and space.

Cultural and genetic information, argued here, enable and maintain human-ecosystems that maximize self-reinforcing energy transformations, that reduce energy gradients, and that develop autocatalytic dissipative structures. Information is the result of the directionality of the universe towards maximum empower and the formation of energy transformation hierarchies. More simply put, information does something. It remembers self-organization, and extends it through time. It permits increased complexification, adding fossil-fuel-enabled scales of economic and information hierarchy upon each other. Information is so much a part of us at so many scales of our lives that it is difficult to appreciate. The value of Odum's information cycle is to untangle information, to expose its formation and utility, and to reconnect information of all forms.

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