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Thinking about Interdisciplinarity:

A Primer for Practice

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Groups of researchers gather each week to initiate, to monitor, and to evaluate interdisciplinary projects. They bring talent and commitment to the table but are often unsure about what interdisciplinary work entails. There is no universal formula. Nevertheless, all projects encounter similar dynamics and challenges. To aid both individuals and groups, I offer the following primer for practice. It is not a set of rules, rather key definitions and a checklist of questions that can be used at all points of the project life cycle. The primer addresses three major questions. How did interdisciplinarity evolve historically? What are the major definitions and institutional formations? And, what does the actual process of research entail?

Historical Development

Increased interest in interdisciplinarity in the late twentieth and early twenty-first centuries led many people think it is in fashion. This is not the first time the concept has been in vogue. In the 1960s and 1970s, interdisciplinarity was heralded as the wave of the future. The concept, however, has a much longer history

that may be divided into roughly five periods. The following overview is not an exhaustive chronicle but a roster of highlights. As individuals and groups discuss key benchmarks, they can expand the list to include precedent and current exemplars in their own fields, thereby refining their common understanding of the concept and their place in its history.

Period I: Classical Beginnings --> Late 19th Ct.

- Ideas of unity, synthesis, integration, and general knowledge
- New synthetic theories: internal relations, vitalism, creative evolution, organicism

The warrants for interdisciplinarity are ancient. They lie in the ideas of unity, synthesis, integration and general knowledge developed in ancient Greek philosophy. The Greek educational program of the *enkuklios paedeia* and the Roman *orbis doctrinae* also provided precedents for a well-rounded multidisciplinary education that surveys the disciplines. The search for unity of knowledge was undermined by increasing specialization, but the underlying ideas of synthesis, holism, and general knowledge were transmitted throughout the history of Western knowledge and culture. New synthetic theories also continued to emerge. At the turn of the twentieth century, as the modern system of disciplinarity was being institutionalized in Europe and America, leading examples included the theories of internal relations, vitalism, creative evolution, and organicism.

Period II: Early Modern Period 1900 -->1940s

- General education movement and core curriculum

• Social science research: SSRC, reform social science, unity of science movement

• Hybrid disciplines and fields: social psychology, biochemistry, area and American studies

• Borrowing of tools and methods: quantitative methods, lasers,
electron microscopy, statistics

With the displacement of liberal humanism from the center of higher education, the generalist tradition of knowledge found a new home in the general education movement that arose in the early twentieth century. Two definitions of interdisciplinarity were apparent from the start, though, one hearkening back to the *studia humanitatis* of the Renaissance and the other engaging the present in a problem focus. In addition, interdisciplinarity was practiced in social sciences, in the work of the Social Science Research Council in the 1920s, the "interactionist" framework, the culture-personality movement in the 1930s and 1940s, and reform social science. Social scientists also borrowed quantitative methods of natural sciences, and influential concepts such as "role" and "status," "information" appeared across disciplines. Hybrid disciplines arose in social psychology and political psychology, while influential movements such as the *Annales* school of social history promoted new syntheses. The most overt effort to integrate scientific inquiry was the Unity of Science campaign to unify the rational and empirical domains through logical positivism. Even this early, interdisciplinary fields were emerging as well, foremost among them comparative literature, American studies, and area studies.

Period III: Mid-Century Expansion 1940s --> Early 1960s

• Renewed general education reform

• New syntheses: general systems theory, structuralism, Marxism

• Rise of IDR (interdisciplinary problem-focused research):

Manhattan project, operations research, agricultural research

• Crossfertilization in human sciences: social history, man-land relationship

in geography, historical-social-economic explanation in literary studies

• Crossfertilization in science: plate tectonics, radio astronomy, molecular biology

By mid-century, the meaning of interdisciplinarity had become more plural. General education reform stirred renewed interest in core knowledge, holistic modes of learning, and the study of common problems and significant issues. New synthetic theories also arose, including Marxism, structuralism, general systems theory, and information theory. World War II was a major turning point, leading to an expanded presence of interdisciplinary laboratories and projects on campus focused on war-time projects such as designing a new turbo engine, building an atomic bomb in the Manhattan Project, and, a key event in the early history of operations research, work on radar systems. Meanwhile, the disciplines were expanding in scope and relations with other disciplines and interdisciplinary fields. In humanities and social sciences, poststructuralism challenged older isolated disciplinary approaches. In earth sciences, the shift from the classical theory of continental drift to modern plate tectonics involved paleontology, geochemistry, marine geology, and geophysics, seismology, volcanology, and paleomagnetism. By the 1950s, the number of hyphenated sciences was growing as well in areas such as biophysics, biochemistry, and biochemical engineering.

Period IV: Escalation in the Reform Era 1960s ---> 1970s

• Educational reforms of 1960s and 1970s and expansion of interdisciplinary studies (IDS)

• New interdisciplinary fields

• NSF's proactive interest in managing IDR, aerospace research, and systems engineering

• Pioneer OECD international seminar and subsequent scholarship on the concept

• Escalating crossfertilization of disciplines in humanities, sciences, social sciences

• New synthetic theories: chaos theory

The 1960s and 1970s was an era of educational innovation and experiment. New structures and programs were founded and the roster of interdisciplinary fields expanded with such notable developments as Black and other ethnic studies, women's studies, environmental studies, urban studies, and science-technology-society studies. Other new fields included cognitive science and materials science and new synthetic frameworks such as chaos theory emerged. All the while, disciplines continued to diversify, and problem-focused research expanded, with the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) taking a proactive interest in studying the management of interdisciplinary research and problem solving in academe, government, and industry. This priority heightened during the 1970s as industrialized nations targeted interdisciplinary priorities in research funding in internationally competitive areas, such as computers, manufacturing, science-based technologies, and biomedicine.

Period V: Expansion and Reevaluation 1980s ----> 1990s

• Expanding interdisciplinary presence in curriculum, mainstreaming in general education

• Expanding interdisciplinary fields: cultural studies, information sciences, gerontology

• Intensified IDR in areas of international economic competition in science-based industries

(manufacturing, computers, biomedicine, high technology), systems engineering

• Pervasive crossfertilization of the disciplines**:** transformation of life sciences, humanities

• Expanding shadow structure of interdisciplinary research, proliferation of centers and institutes new alliances among government-university-industry, matrix structures, hybrid communities and enclaves, collaborative research and interstitutional projects

• Growing diversity and complexity of contemporary disciplines and professions

• Rise of critical interdisciplinarities, critique of disciplinarity, discourse of post-disciplinarity

• New momentum for transdisciplinary sustainability research

Interest in interdisciplinarity intensified at the turn of a new century. Its role expanded across the curriculum, becoming a priority in general education reform. New fields emerged alongside older ones, the perception that interdisciplinarity is a major force in the disciplines widened, alternative networks and enclaves increased in number, and cultural critique challenged older disciplinary constructs. New critical paradigms not only transgress disciplinary boundaries, they often engage the imperative of ethics and socio-political justice. At the same time industrialized nations continued to prioritize interdisciplinary research in science- and technology-based industries and a new imperative for "transdisciplinary" problem solving in the realms of industrial application as well as the environmental and community sustainability.

Definition and Institutionalization

Framed by this historical background, a number of definitions have emerged. Three are basic for any project.

Multidisciplinary approaches juxtapose disciplinary/professional perspectives, adding breadth and increasing available knowledge, information, and methods. Yet, they speak as separate voices, in encyclopedic alignment rather than an integrated fashion. The status quo is not interrogated and disciplinary elements retain their disciplinary identity.

Interdisciplinary approaches integrate separate disciplinary data, methods, tools, concepts, and theories in order to create a holistic view or common understanding of a complex issue, question, or problem. Several important distinctions also appear in the literature. **"Instrumental," "strategic." "pragmatic" or "opportunistic" interdisciplinarities** focused on economic, technological, and scientific problem-solving differ from **"critical" and "reflexive" interdisciplinarities** that interrogate and in some instances aim to replace the existing structure of knowledge and education. The radical formulation of critical interdisciplinarity posits an "anti-disciplinary" and "post-disciplinary" stance that rejects disciplines in whole or in part. Theories premised on **unity of knowledge** also differ from **a complex, dynamic web or system** of relations and practices. Scope differs as well. "**Narrow interdisciplinarity**" involves disciplines with more or less the same paradigms and methods. In **"broad interdisciplinarity,"** the paradigms and methods of participating disciplines differ.

Transdisciplinary approaches are comprehensive frameworks that transcend the narrow scope of disciplinary worldviews through an overarching synthesis, such as general systems, structuralism, Marxism, policy sciences, feminism, and sociobiology. The term is also being used today used to signify a new structure of unity informed by the worldview of complexity in science, a new mode of knowledge production that fosters a synthetic reconfiguration and recontextualization of available knowledge by drawing on expertise from a

wider range of organizations and stakeholders, and collaborative partnerships for sustainability that cross not only disciplinary boundaries but social sectors in problem- and solution oriented research.

Institutional Formations

Institutional formations vary in kind and levels of formality and visibility.

LEVEL I: Interdisciplinary Institutions

- Interdisciplinary universities
- Universities and colleges with an interdisciplinary milieu

During the 1960s and 1970s, a number of interdisciplinary universities were founded. The academic system was not radically transformed, but the structures of research and education introduced in these experiments continue to be adapted and new structures arise. Some institutions also had an interdisciplinary milieu already and, in the late twentieth century, interdisciplinarity became a high priority in many strategic plans. By and large, the more typical site is a program or center rather than a department, a college, or a full-fledged university.

LEVEL II: Interdisciplinary Sites

- Interdisciplinary studies programs (IDS)

• Research centers and institutes

• Interdisciplinary majors, minors, concentrations

• Interdisciplinary honors programs

• Course sequences, clustered courses, individual courses

• Self-designed majors, masters, and Ph.D.s; independent studies

• Professional training

Many interdisciplinary projects and programs are located in what has been called the "hidden" university" or "shadow structure" of the academy. Interdisciplinary studies (IDS) are homes for teaching and research in an immense array of fields that develop new categories of knowledge. Their structures vary, from an augmented form of specialization or a multidisciplinary array of existing courses to a full-fledged program with its own interdisciplinary seminars and, in rarer cases, an autonomous department, school, or college. Centers and institutes are primarily sites of research that augment departmental structures in an equally wide range of areas. The portfolios of centers range from discipline-dominated projects to multidisciplinary activities to interdisciplinary forums for collaborative teamwork and cross-campus dialogue. Although both interdisciplinary fields and centers may struggle with problems of marginality and visibility, they, and other IDS programs, document a long-term structural change in the academy driven by the accretion of problem-, theme-, and topic-focus.

LEVEL III: Interfaces

• Hybrid disciplines and subdisciplinary fields and interests

• Joint appointments of faculty, crosslisting of courses

• Common facilities, data bases, instrumentation

• New alliances with government and industry for commercial knowledge production

• Local, regional, national, and international programs and projects

One of the notable trends in the history of the academy is the growth of hybrid social communities and "trading zones" of exchange where individuals from different backgrounds interact. The emergence of a hybrid discipline is the most formal signal of shared interests, though interactions at the subspecialty level are important indicators. Multidisciplinary labs and interdisciplinary projects have also become more prominent in science and industry and, across all sectors, new scholarly networks formed. The signals include, as well, the emergence of new scholarly literatures, advertisements for faculty hires in new areas, joint appointments in departments and centers or programs, the restructuring of traditional departments, and participation in regional, national, and international projects and other initiatives that involve multiple disciplines and institutions.

LEVEL IV: Invisible Colleges and Interdisciplinary Traffic

• Shared problem domain (intellectual, technological, social)

• Migration of specialists

• Borrowing of tools, methods, approaches, and concepts

• Crossfertilization and interdisciplinary traffic across boundaries

• Complexity

• Conferences and symposia on state-of-the art and cutting-edge practices

• New interdisciplinary knowledge production published in journals and books

• Networks, interest groups, and study groups

LEVEL V: Disciplinary Presence ("grass roots")

• Interdisciplinary schools of thought, approaches, methods

• Interdisciplinary histories

• Disciplinary change in research and curriculum

• Jobs for specialists in new fields

• Traffic between departments and centers and programs

• Traffic between research and curriculum

Both Levels IV and V bring to mind an old administrative saw -- interdisciplinary activities exist in the white space on institutional charts. By the dawn of the twenty-first century, the white space was more crowded than ever. Standard indicators such as traditional knowledge taxonomies, organizational charts and course catalogues, library classification schemes and information databases, and publishers' marketing categories minimize or obscure the full extent of boundary crossing that is occurring. If the starting point is altered – to what the people are actually doing in the knowledge system -- the answer changes. A significant amount of activity is occurring in less visible forms, including the quiet daily flow of influence born of borrowing methods and concepts, the migration of specialists to new problems, participation in interdisciplinary fields, and the knowledge production that ensues from interdisciplinary conferences and symposia. The least visible activity is often the grass roots presence in disciplines, in the incorporation of new interdisciplinary developments.

Process and Evaluation

For all the talk about interdisciplinarity, not a lot has been written on the process of actually doing it and how to evaluate it. The following checklist, culled from the wisdom of practice, provides categories of questions that may serve as touchstones for discussion and assessment at all points of a project's lifecycle.

CATEGORY A: Initial Phase

The initial phase is crucial. Individuals with different disciplinary languages and worldviews need to arrive at a common conception of their work. Commonality does not mean uniformity, rather a shared understanding of the task at hand. Without it, results will be either multidisciplinary or a collection of disciplinary inputs at best. The key action is collaborative definition of the research problem and research questions, the project's goals and objectives, a spectrum of work that is neither too narrow nor too broad for the task at hand, and relevant approaches, tools, and partners.

1. Has the research problem been defined collaboratively?
2. Have project goals, objectives, and research questions been determined collaboratively?
3. Have relevant variables and categories been identified? (e.g., disciplinary, professional, interdisciplinary, cultural)
4. Has the spectrum of relevant disciplines, professions, and interdisciplinary fields been identified and their relationship been clarified?
5. Is the spectrum of too narrow or broad for the task at hand?
6. Have relevant approaches been identified? (e.g. concepts, theories, methods, tools)

7. Have partners and the audience for research been identified in pertinent research communities and public or and private organizations? Will their role be a collaborative or a contracting mode?

CATEGORY B: Organizational and Conceptual Framework

Every interdisciplinary project constitutes a hybrid community based on a mutual design that is both comprehensive and feasible. State-of-the art knowledge is required from not only pertinent disciplines but also pertinent professions and interdisciplinary fields. Interdisciplinary work is neither linear nor predictable. It is complex, with feedbacks loops to different stages of the work. Hence, flexibility is important, allowing for refining the framework as needed and any shifting groupings of individuals and approaches.

8. Is the research design a mutual plan?
9. Has the research problem been defined with regard for what is significant, on the one hand, and possible, on the other hand? Is the scope comprehensive enough to address major aspects but still feasible given the material and human resources?
10. Are selected approaches appropriate to the problem, and do they reflect state-of-the-art knowledge in participating disciplines, professions, and interdisciplinary fields?
11. Is there flexibility to allow for shifting groupings of individuals and approaches as research evolves?

CATEGORY C: Social Learning and Communication

Mutual learning is crucial. Because participants do not bring the same expertise, they must clarify their differences and their roles. Conflict is inevitable and must be used creatively, rather than ignored. Language is crucial. Projects generate a common *lingua franca* that is typically a hybrid of specialized terms and everyday vocabulary. Provision for ongoing communication is essential, in order to capture the knowledge production that is occurring and to support consultation with other groups.

12. Have participants engaged in role clarification and negotiation, to define what they need from each other and can contribute?
13. Have participants clarified differences in their disciplinary assumptions, language, methods, tools, concepts, theories, epistemologies and ideologies?
14. Has provision been made for time to learn from other team members?
15. Is there a plan for regular in/formal communication and exchange of data? (e.g., electronic communication through email and listservs, f2f meetings, interactive video conferencing, collaborative research and fieldwork)
16. When conflicts arise, are they ignored or used creatively to refine and advance the project?
17. Has the team created a "pidgin" (interim language of communication that is a “local colloquial” or “trade” tongue) and a “creole” (a new subculture or native language)?
18. Is there provision for communication with other teams in large projects, to share ideas, techniques, and results?
19. Is there a plan for capturing the knowledge produced in a project? (e.g. conceptual papers and reports; instrumental products such as graphs, data matrices; ephemeral products such as representations, whiteboard diagrams, flip charts,

transcripts, notes; results of tools used for managing data and decision making such as computers, shared text editors and drawing media, audio and/or video recording devices; email and snailmail exchanges).

CATEGORY D: Collaboration and Integration

The heart of interdisciplinary process is integration, and in teamwork, collaboration. Young teams, Anthony Stone suggested, lean toward the model of secondary-group relations that is protective of the individual. Older teams move toward primary-group relations that reflect dedication to a common task and shared cognitive framework, shifting from the consciousness of "I" to "we." Integration should not be delayed but be ongoing throughout all phases of a project, with sustained interaction, coordination, and reflection. Synthesis unfolds in patterning and testing the mutual relatedness of materials, ideas, and methods to the task at hand. Ultimately, both individuals and the conceptualization of a project change as a result.

20. Do the structure and work plan facilitate interaction?
21. Has attention been paid to how tasks will be coordinated in the timetable?
    Will participants work jointly or in separate, serial fashion?
22. Will integration be on-going, not delayed to a final phase?
23. Does the team engage in joint activities (e.g. co-authorship of working papers and publications; presentations, workshops, and seminars; interim and final reports to funders and other groups; joint patent or legislative work, practical applications)
24. Does the team work with common instruments? (e.g. data-reporting forms, data gathering

and analysis, procedures, equipment, facilities)

25. Is iteration used to achieve common assessments and products? (e.g. peer reading, editing, critiquing of each other's work components; reviewing initial assumptions on a recurring basis and returning to earlier stages to appraise individual contributions and collective resolution of differences; revisiting of provisional conclusions)
26. Are known interdisciplinary techniques utilized? (e.g., Delphi method, scenario analysis, general systems theory, brainstorming; models of interdisciplinary process)
27. Has the synergy of "teamness" evolved, moving from the secondary-group relation of the self-protective "I" to the primary-group relation of the common "we"? Have collegiality and trust been established, defined by honesty, openness, consistency, and respect?
28. Is the disciplinary/professional balance of power equal, or are some disciplines/individuals subordinated to a reductive role (data supplier or "findings," an additive but not an integrative partner, or explanatory background or context)?
29. Is the outcome an interdependent, collaborative synthesis or multidisciplinary compilation of separate inputs on different phenomena, or only data sharing?
30. Is there a unifying principle, theory, or set of questions that provides coherence and/or unity? Are salient concepts and global questions used to foster integration?
31. Is there collective reflection on the interdisciplinary and collaborative nature of the work, including the kind of interdisciplinarity that is being practiced?
32. Are depth, breadth, and synthesis triangulated in an organic process?
33. Have participants changed as a result of the process, beginning to think in a new way?
34. Did the conception of the project shift over time?

CATEGORY E: Evaluation, Innovation, and Dissemination

Evaluation is the most neglected aspect of interdisciplinary projects. Like integration, it should not be delayed but must be continuous. The task of evaluation is compounded by the presence of multiple disciplines. Each carries specific and sometimes conflicting assumptions about quality. The presence of non-academic stakeholders introduce added variables. Multiple methods and perspectives are required, both quantitative and qualitative. Ongoing evaluation also provides for feedback loops that improve the research process and, the conceptual framework. Dissemination of results and implementation of new models of research and education are crucial to the long-term sustainability of project goals and outcomes.

35. Has provision been made for evaluating interdisciplinary, collaborative aspects of the work?
36. Were criteria defined collaboratively? Is evaluation ongoing, not delayed to the final phase?
37. Does the project lead to development of new knowledge, research topics, models and processes, curriculum, action plans?
38. Are gaps between academic, non-academic, and public discourses bridged?
39. Will results be articulated in the public health arena and on accessible electronic sites/tools?
40. Will pilot projects and bridging mechanisms have long-term impact?
41. Will results be articulated to pertinent disciplines, professions, and interdisciplinary

fields?

42. Will results of research be shared with the general public and pertinent community groups?

Resources

The literature on interdisciplinary is not a single literature but many. Moreover, pertinent resources are dispersed across a wide expanse. Finding them requires two strategies: using key works in the literature, which covers the "basics" and leads to further references, and networking and electronic database searching, which broadens the scope of information and insights. The following bibliography highlights key references in six areas: the concept of interdisciplinarity; science, technology, and sustainability; management of research; models of process and collaboration; education; and national reports.

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Networking and Database Searching

Networking involves both face-to-face and electronic contacts with individuals and related projects and organizations. Asking direct questions about resources expedites access to resources and lessens the sense of isolation that individuals and teams experience. Numerous groups cover a wide range of disciplinary and interdisciplinary topics. Some are open to anyone, but others restrict access to members. Several noteworthy

services gather and evaluate information websites. Argus Clearinghouse (http://www.clearinghouse.net/) and Scout Report (http://scout.wisc.edu/report/sr/current) identify listservs. So does the humanities- and social science-based H-NET (http://www2.h-net.msu.edu/lists). The Scholarly Societies Project of the University of Waterloo Electronic Library is a clearinghouse with links to over a thousand professional associations and individual websites (http://www.lib.uwaterloo.ca/society/overview.html). Anthony Judge offers a compilation of websites on integrative knowledge (laetusinpraesens.org/links/webkon.php) and, in the realm of sustainability, TD-NET provides bibliography and information services, a discussion forum, and links to other sites (http://www.transdisciplinarity.ch). The International Center for Transdisciplinary Research is a non-profit based organization that develops research on a new scientific and cultural approach (http://perso.club-internet.fr/nicol/ciret/).

The challenge of locating knowledge and information is compounded in interdisciplinary projects by the problem of "scatter." Pertinent sources are dispersed across multiple disciplines, professions, and interdisciplinary fields. Consequently, interdisciplinary searching requires going beyond the usual search for books and periodicals. Many online disciplinary, multidisciplinary, or topic-oriented databases are only available in their complete form through subscription, but they may well be available in the local academic library. That is always the first place to check.

Other useful resources include specialized databases and multidisciplinary print and online indexes and abstracting services. The Wilson Indexes cover 200-400 selected journals in disciplinary clusters (e.g., General Science, Applied Science and Technology, Social Sciences Index, Humanities, Art, Business, Education). Print and online encyclopedias, dictionaries, and handbooks also provide entry into fields that may be new to a scholar. As always, consulting with librarians will also yield pertinent resources in special collections, archives, and specialized libraries.

The Institute for Scientific Information (ISI) merits special mention. Their products cover the most frequently cited journal titles. The Current Contents® database makes available tables of contents for journals in arts and humanities, social sciences and sciences. The citation indexes (Arts and Humanities Citation Index™, Social Science Citation Index™, Science Citation Index™) help in tracing how a seminal article has been used in more recent articles, tracking forward in time.

The problem of scatter also required identifying synonyms or alternative terminology appropriate to particular databases outside one's field. New interdisciplinary terms and topics, Stacey Kimmel suggests, may run ahead of existing subject headings, The first step may be to "retrofit" them or, if matches can't be found, to engage in free-text searching. Carefully constructed "keyword" searches will produce a wider overview of resources. The issue of terminology arises particularly in what is sometimes called "federated searching."

Federated searching is the use of an interface that allows simultaneous integrated access to or searching of a variety of databases. It may be used across databases provided by one vendor or a software that will search across databases from different producers or vendors. Federated searching allows efficient grouping of databases useful for interdisciplinary or multidisciplinary topics. To reiterate, the terminology of an interdisciplinary topic may vary across fields, and search strategies in federated searching must take that factor into account. (One source of information on federated searching is a PowerPoint presentation by Cheri Duncan of James Madison University [www.viva.lib.va.us/viva/tech/cat/ link/Federated%20Searching.ppt]).

Alert services can also be set up for subscription databases through vendors, such as OVID, that will run a search each time the selected database is updated. The alert provides a list of citations corresponding to the search without having to run it at regular intervals. This service is particularly helpful with databases that provide tables of contents of scholarly journals, such as Project Muse.

Finally, numerous useful sources of information are freely posted on the Internet by individuals, associations or institutions that can be identified by using search engines such as Google™. Beaucoup!

<www.beaucoup.com> lists search engines, webpage indices and directories. Authors of rich web sites write contextual information, list bibliographic information for seminal books or journal articles, and annotate links to related websites. Such sites are capable of integrating a variety of resources and communicating the interdisciplinarity of topics. For instance, the Voice of the Shuttle (vos.ucsb.edu/) covers the humanities. Begun as a series of static pages, it has been reorganized as an extensive open-ended database that continues to grow.

Works Cited

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