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# Transforming the Web into an open-access knowledge-repository with easier knowledge-creation and faster publication, by means of open-source software for MetaLinks and for AEC-Forums which also enhance post-graduate education.

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**NB:** The paragraphs are sequentially numbered for *purposes of discussion*, at the lower right corner, in curly brackets, as shown here--->. {1}

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## Abstract

(To find full Definitions of New Terms, see **Contents** above, containing "**Definitions**")

"Publication forms the core structure supporting the development and transmission of scientific knowledge" [Galibraith2015]. Yet, with the WorldWideWeb a dominant part of many activities, "publication" is still ***paper-based*** in its ***style and methods***, even when it uses a *digital medium*. ***Such a paper-based "system" is not optimal for a Web-based world!*** {2}

In 2006, an estimated **3,700 peer-reviewed articles were published per day** [Bjork2009]! As will become apparent, the methods and features described here are *needed* ***now***, and will be ***absolutely necessary*** *in the* ***future***, when even more articles are published. {3}

*The amount and rate* of **Knowledge-Creation** with presently-available **Knowledge-Tools** *does not keep up* with the Information-Expansion that has occurred with expanded scientific and academic activity. *Contributing to this failure* are 1) **inefficient present-day Knowledge-Tools,** and 2) **insufficient numbers of human Knowledge-Compenders**. Both issues are directly addressed in this Article, which proposes *New* Knowledge-Tools, ***in addition*** *to those already available*. These Knowledge-Tools are 1) AEC-Forums, and 2) MetaLinks, both being made operational by means of Open-Source Software created by this Project. {4}

Regarding AEC-Forums, they will provide an easy way to create AEC-Compendia (a ***concise, yet comprehensive, evaluation*** of earlier work, where the acronym "AEC" stands for the phases during Compendium-Creation: **A**ggregate, **E**valuate, and **C**onsolidate). In an online AEC-Forum (built and operated within the Open-Source Software of this Project), a group of experts will *create new Knowledge on a Narrow-Topic*, *in a MultiLevel Format that reveals the "structure" of the Narrow-Topic.* Repeated "Steps" of AEC-Compending build Knowledge into forms needed to both advance a field and better teach it. {5}

There will also be an enhancement of **Post-Graduate Education** because Post-Graduate Students can easily become Knowledge-Compenders by setting up and running an AEC-Forum to create an online AEC-Compendium. This activity will provide an educational experience usually not encountered so early in a scholar's career. The Student will be motivated by self-interest because the Forum can provide the scholarly



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basis of a thesis-topic, as well as providing contact with experts who may be the source of future friendships and jobs. {6}

With regard to MetaLink-Software, the MetaLink-Protocol will improve WebLinkages between AEC-Compendia and Articles in Active Archives. A MetaLink is a WebLink in an online WebSite that provides considerable MetaData known to be of interest to Readers. Means are provided within the Protocol for adapting the MetaData-Categories to the different needs of different fields, and to the changing needs of a changing field. Such enhanced WebLinks will be **available directly on *any* WebSite using the Project's Open-Source Software to comply with the MetaLink-Protocol.** Unlike present-day "backlinks", all MetaLinks will be from *Sentence-to-Sentence*, even when a MetaLink points forwards-in-time (a ForwardLink). {7}

The Project has been designed so *it does not need continual funding, nor top-down control. When widely used, the Open-Source Software will make the future Web, by itself,* ***a complete self-sustaining Knowledge-Repository that can be used by scholars more easily and efficiently than the present Web***. {8}

## Introduction:

### Intro.1 Author's Comment

This Project started small, but it gradually became larger as the solution to one problem solved another problem outside of the original goals. This occurred several times. To see how all the pieces fit together, jig-saw style, this article is *much* longer and detailed than a usual submission. The Author hopes you, the Reader, will find your time reading this well spent. If some parts are too detailed for reading at this time, it may be advantageous to jump ahead to other parts using the Contents page (above) as a guide. {9}

### Intro.2 Where We Are

As Galbraith has said "Publication forms the core structure supporting the development and transmission of scientific knowledge." [Galbraith2015]. The Internet and the Web (World Wide We2) have revolutionized publication and information access. Libraries have discontinued many "paper" journals in favor of online subscriptions for students and faculty. Open-Access publication of publically-funded research is now common,



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though not universal (perhaps 20%). But "Publication" is still *Paper-based* in its ***style and methods***, even when it is in a *digital medium*. ***A paper-based "system" is not optimal for a Web-based world!*** {10}

Question: Will further adaptations to the paper-based publishing-model be sufficient for present and future needs? This article strongly argues "**No**"; the methods and features *to be added to those that are currently available* are *needed* ***now***, and will be ***absolutely necessary*** *in the* ***future***, when even more articles are published. To explain this, first let's distinguish between Information and Knowledge. {11}

### Intro.3 A Maxim

The Author has composed a maxim for Science and Medicine:

Numbers *alone* are ***not*** Data;
Data *alone* are ***not*** Results;
Results *alone* are ***not*** Information;
Information *alone* is ***not*** Knowledge;
Knowledge *alone* is ***not*** Wisdom. {12}

The statement "Information is not Knowledge" is a phrase from a song by Frank Zappa. (The authorship has been erroneously ascribed to Einstein.) Discovering the phrase stimulated the Author to both write the maxim, and to puzzle about how Knowledge was actually created. The Author, despite decades dedicated to Medical Research and Teaching had never considered *in any detail* the means by which Research Information was turned into Medical or Scientific Knowledge. Information and Knowledge were jumbled together, in research articles, textbooks, and thoughts.

If Zappa's phrase is correct, then **by what means does Scientific Information become Scientific Knowledge?** For the Author's answer, see Fig.1. {13}

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### Intro.4 Knowledge Paths

Fig. 1: Knowledge-Paths from Information to Knowledge.

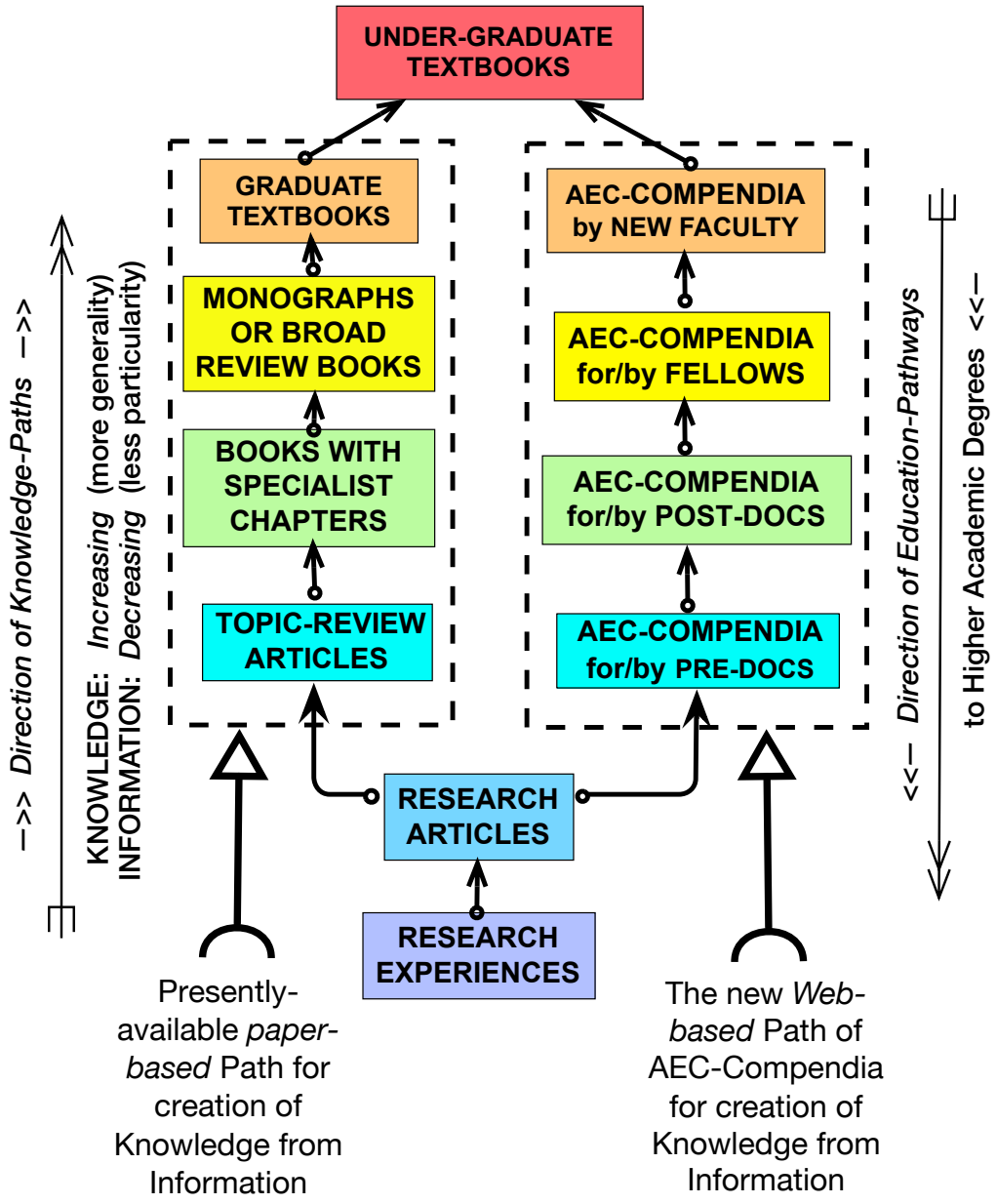


Fig. 1 Legend: As Knowledge is created from Experience, Information, and prior Knowledge, multiple steps are needed to make the Knowledge useful, and used. Two Knowledge-Paths are shown (in two columns): 1) the presently-available paper-based system (*left* column), and 2) the Web-Based AEC-Compendia method proposed here (*right* column). The differences between the two Paths are a main subject of this article. {14}



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Fig. 1 illustrates a number of important points:

1. Moving upward in the Figure, from one publication-type to the next, Information ***decreases*** (there is less particularity), while Knowledge ***increases*** (there is more generality).
2. As Knowledge increases by Knowledge-Creation, the decreased particularity and increased generality make it easier to learn a given Knowledge level. With successful consolidation in the Knowledge-Steps, students traversing the Education-Pathway can master the material more rapidly than the Knowledge-Consolidators of the Knowledge-Path were able to do so (before consolidation).
3. At the top of the Figure, Under-Grad Textbooks form the start of the Education-Pathway by which the next generation of scholars learns a given field. The Education-Pathways are the same as the Knowledge-Paths, except that the Education-Pathways are traversed ***downwards in the Figure,*** whereas the Paths of Knowledge-Creation are traversed ***upwards in the Figure.***
4. It is notable that written material, considered as either a Knowledge-Path or an Education-Pathway, differs with respect to the different "levels" of the intended readership. These "levels" are the same in both Paths, as indicated by the matching fill-in colors in both Paths.
5. Whereas the paper-based Path is presently well-known, with established (yet inefficient) methods, the AEC-Compendia Path involves ***new Knowledge-Tools to be available in addition to the present Tools.*** {15}

Definitions of the terminology, given next, may aid in understanding Figure 1.

## Intro.5 Definitions, Compend

**Compend** (verb) = to weigh, compare, assess, or evaluate several items together.

**Compendium** = a scholarly publication that is ***a concise, yet comprehensive, overview of earlier work***. (plural = Compendia) The words 'concise' and 'comprehensive' can imply a contradiction--- however it is possible to do both using a MultiLevel-Format (see Methods).

**AEC** = Acronym for the combined phases of Web-Compending: 1) **A**ggregate; 2) **E**valuate, and 3) **C**onsolidate. These phases are described in Intro.6, below.

**AEC-Compendium** = a Compendium created using AEC, and presented in a MultiLevel-Format (see Methods). As a practical matter, AEC-Compendia can be



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hosted on the Web in the AEC-Forum WebSites in which they were created, or in institutional Active Archives (Link.12, below).

**AEC-Forum** = an online WebSite where a Consolidator, together with other scholars create a new Knowledge-Step (a Compendium) using AEC. An AEC-Forum utilizes **some** of the features of present online forums and blogs, but has **additional features** that neither has. Thus, AEC-Forums require special Software.

**AEC-Consolidator** = the organizer of an AEC-Forum.

**AEC-Scholar** = a scholar who uses AEC to create Knowledge-Steps (usually within an AEC-Forum).

**Knowledge-Tool** = a mechanism that aids scholars during creation of knowledge.

**Knowledge-Step** = a publication describing one part of a Knowledge-Path.

**Knowledge-Path** = a sequence of Knowledge-Steps, wherein, moving along the sequence, the Knowledge-generality ***increases*** while the Information-particularity ***decreases*** (see Fig. 1). Moving in the opposite direction in the sequence is named the Education-Pathway (*q.v.* below; see Fig. 1).

**Knowledge-Consolidator** = a scholar who uses Knowledge-Tools to create the next Knowledge-Step in a given Knowledge-Path.

**Education-Pathway** = the collected Steps of a Knowledge-Path, sufficiently-developed for educational purposes. NB: When moving on the Education-Pathway the Knowledge-generality *decreases*, and the Information-particularity *increases. This is opposite of the changes when moving along a Knowledge-Path.* {16}

### Intro.6 Description of the AEC phases

The phases of Web-Compending when creating an AEC-Compendium are:

1) **A**ggregate; 2) **E**valuate, and 3) **C**onsolidate. These actions apply to the Information and Knowledge being Web-Compended into a Knowledge-Step:

1. First, the available Information and Knowledge are **A**ggregated, *i.e.,* they are brought together explicitly so they can be processed.
2. Second, the Information and Knowledge are **E**valuated, *i.e.,* are understood, and then "weighed" against one-another, being judged for their suitability for the Knowledge-Step and the expected Readership.
3. Third, the content is **C**onsolidated, *i.e.*, organized and shortened into a form that can be easily understood and used by the expected Readership.

These actions will create a Knowledge-Step that contributes to the efficient creation of the ***next*** Knowledge-Step in the Knowledge-Path, by being both comprehensive (in the Aggregate phase) and concise (by use of the MultiLevel-Format [described later]). {17}



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### Intro.7 Costs

The creation of Scientific-Knowledge from Research-Experience (Information) can involve many steps. The number of steps necessary to reach a given level depends on who is to receive and utilize the Knowledge.

*NB*: **each step** requires *human* **effort**, *human* **ingenuity**, and, *most critically, human* **time**. The extra time needed to make a complicated issue concise and clear has been known for centuries. In 1657, Blaise Pascal wrote "I have made this [letter] longer than usual, only because I have not had the time to make it shorter." [Oxford1997]. {18}

The resources needed to create a full Path clearly involves considerable human "cost" in "time and effort". It is *not cheap* to makes things *simple*. *Au contraire.* In which case, the question of "who pays" inevitably arises.

The "Standard Path" (based on the Paper-Publishing Model) has notable ***limitations*** **based on financial issues at *all steps***: Will an Article or Topic-Review keep present reader subscriptions at a profit level? Will a Monograph or Book sell enough copies to cover the "costs" (of the Publisher's other books that are losing money)? Will a Textbook sell to more than the Author's own students? {19}

The proposed Web-Based AEC-Compendia Path has **no financial-limitations**, because: 1) all posting is Open-Access (no subscription-limitation on readership); 2) there are no "authorship" charges; and 3) the only (small) funds required by an Author are for WebHosting time (if at all). The remaining Limitations are those due to the limits of human time. {20}

### Intro.8 Increasing numbers of specialities

Addressing now the larger picture: With increasing numbers of scholars, specialists, fellows, and faculty involved in scientific and medical research, it is not surprising that the *number* of both publications and specialized "fields" is increasing as more Information is acquired and more Knowledge is created. What may be surprising is that the ***increasing numbers*** of specialized fields indicates that ***the number*** of specialists **required to** *learn, remember, and utilize* the increased Information and knowledge *of each field* ***is also increasing***! {21}

Question: Why isn't the Knowledge being sufficiently compended so that present specialists can learn and incorporate the Knowledge into existing specialities?



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Answer: This occurs because each specialist (being human) has limitations in learning capacity and also has a limited time available to reach a given vocational level. From the increased number of specialist-fields, each field with new, additional specialists, it follows that the ***amount and rate*** of Knowledge-Compending with presently-available Knowledge-Tools ***does not keep up*** with the Information-Expansion that occurs with expanded scientific and academic activity.

This *failure can be mitigated by:* 1) ***more efficient Knowledge-Tools,*** and 2) ***Larger numbers of human Knowledge-Compenders***. **Both** of these topics **are directly addressed in this Article.** {22}

### Intro.9 Knowledge-Tools: past, present, and future

**In the past,** the primary Knowledge-Tools consisted of (paper-based) Libraries equipped with:

1. Books;
2. Journals with Articles;
3. Catalogs & Indexes.

**Presently,** Knowledge-Tools consist of Libraries with mixed media:

1. Books, some paper-based, some on WebSites;
2. Journals with Articles, some paper-based, some on WebSites;
3. Indexing-WebSites with WebLinks that provide some MetaData (such as Authors, Titles, Fields, Keywords, Backlinks), *but which lack further MetaData that would otherwise be of considerable help to Readers.* {23}

**In the future,** Knowledge-Tools *on the Web* should consist of the following:

1. Books on WebSites;
2. Journal-WebSites with Articles (unchanged from the present **or with the MetaLink-Protocol added**);
3. Indexing-WebSites (unchanged from the present **or with the MetaLink-Protocol added**);
4. **New AEC-Compendia WebSites (with MetaLinks)** providing specialized (MultiLevel) summaries of the literature of a narrow topic, created *via* AEC-Forum Software;
5. **New Preprint-Critique WebSites** using AEC-Forum Software, which will provide an easy method for Authors to obtain and use critiques of their work. The AEC-Forum Software will also provide protection against plagiarism (see Node.12);
6. **New Active Archives** whose content does not change, but does create new ForwardLinks whenever a newer-Article cites an Article in the Archive (see Link.2



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and Link.10). Open-Source MetaLink Software created in this Project, when adopted by Open-Access Archives, will make the ***Web itself*** as **an easily searchable, fully-linked Open-Access Knowledge-Repository**.

7. **Active Archives** (see Link.10) **converted from older Passive Archives** will make the older scholarly literature more valuable to scholars who can use the ForwardLinks accumulating on older Articles to follow developments into the current literature (see Link.11). These older Articles (in Active Archives) will become parts of Knowledge-Slices on the Web (see Link.13). {24}

### Intro.10 Summary

Summarizing the Answer to "By what means does Scientific Information become Scientific Knowledge?": Knowledge is created by Scholars into Knowledge-Steps, using the Knowledge-Tools that are available to them at the time. In general, each Compending creates only one "step" in the Knowledge-Path. A notable problem is that each step has financial limitations in the "Paper-based" publishing model. One focus of this article is the use of AEC-Forums to generate Knowledge-Steps consisting of AEC-Compendia in a MultiLevel-Format that are "published" by posting on the Web. The other focus, MetaLinks, is a new Knowledge-Tool that will make it much easier and faster for a scholar to find related Articles, Preprint-Critiques, AEC-Compendia, AEC-Forums, and Active Archives. {25}

Can the rate of *Knowledge-Creation* be increased? **Yes.** But increasing the rate of Knowledge-Creation *will involve adopting AEC-Compendia with a MultiLevel-Format as a new, additional alternative for "online publication" of narrow-topic Reviews.*

Increasing the rate of Knowledge-Creation will also require ***recruiting*** new ***Knowledge-Compenders***.

Both of these changes will be **voluntarily accepted** (rather than imposed) because ***participation in these changes*** will be ***driven primarily*** by the ***self-interest of each individual participant*** (see Node.8 and Node.10). {26}

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## **Methods**:

Both *new Nodes and new Links* on the Web will be required to supply efficient Knowledge-Tools for scholars, and to establish the Web as a ***Knowledge-Repository***. The new **Nodes** are described in **Sections labelled "Node.#"**. Descriptions of the new **Links** then follow in **Sections labelled "Link.#"**. {27}

### **Nodes:**

*Nodes in this Article are WebSites* that host AEC-Forums by which AEC-Compendia are created, reviewed, modified, and displayed. The design of AEC-Forums also allows AEC-Forums to be used for *Preprint-Critiques*.

The *format of AEC-Compendia* proposed here was influenced by the needs of both builders of the Knowledge-Path, and of Readers (Fig. 1). {28}

#### **Node.1 Definitions, Format**

**MultiLevel Format** = a format for presentation, which uses typographical conventions (explicitly defined by the Author), to distinguish different "Levels" of content within the writing [Jewett1981]. A MultiLevel Format provides *different readers* access to *different content*, making the writing less linear and more multi-path. It also provides the *same reader* with content at the level needed by *that reader at that time.*

**Stronger Inference** = the Author's revision of Platt's "Strong Inference" [Platt1964], such that the process **starts with an *observation*** that cannot be adequately explained by existing knowledge [Jewett2005]. {29}

#### **Node.2 A MultiLevel Format for AEC-Compendia.**

Each Compendium should be devoted to a *Narrow-Topic, since a* Narrow-Topic keeps the Compendium contents focused on the issues of the Topic, and avoids branching to associated topics that may be best covered by *another* Compendium.

In building a Knowledge-Path, a MultiLevel Format for each Compendium-step will improve efficiency (*i.e.,* reduce time and effort, ***both*** **in** writing ***and*** in reading**!**). {30}

The design of the Compendium-Format has two mutually-***reinforcing*** goals:

1. To be ***easy to create*** (by concentrating on the basic "structure", *i.e.*, the core ideas



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of the Narrow-Topic; and by organizing the presentation in a MultiLevel Format).

2. To be ***easy to comprehend*** (by the simplification derived from concentrating on the basic "structure", and by the use of the MultiLevel Format).

The way that the MultiLevel Format aids *both of these goals* will be shown after a description of the MultiLevel Format. {31}

One proposed MultiLevel Format for AEC-Compendia will contain **Three Main Sections, each with multiple Levels,** as shown in Fig. 2.

Fig. 2: Sections and MultiLevel expansions for a Compendium-Format.

| **Sections** ⇓ **Levels** ⇒ | **Level 0 Starting Point** | **Level -1 Expansion** | **Level -2 Further Expansion** |
|---|---|---|---|
| **ASSERTIONS** what we -- KNOW -- | A List of **Assertions** | For ***each Assertion***, available Evidence: Description & critical Evaluation | For ***each Evidence:*** Methods for new Evidence for/ against Assertion |
| **CONJECTURES** what we -- HOPE to KNOW -- | A List of **Conjectures** | For ***each Conjecture***, Reasons for/ against with Summary & critical Evaluation | For ***each Reason:*** possible Methods for/against Conjecture |
| **STRONGER INFERENCE** what we -- DON'T KNOW -- | A List of **Observations,** ***not yet understood*** | For ***each Observation:*** alternative, *testable* Hypotheses | For ***each testable Hypothesis:*** Methods for critical Evidence for/ against |

Fig. 2 Legend: A MultiLevel-Format. On the vertical dimension of different Sections, the range of possible Knowledge about the topic is covered by what we: 1) Know, 2) Hope to Know, and 3) Don't Know. On the horizontal dimension of the expansion of a Section, the evidence is presented and evaluated, so that possible pathways are described by which to improve the knowledge of the topic. {32}



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The three Sections (Fig. 2, vertical dimension) cover the range of what we know about a given (narrow) Topic. Each Section can be easily expanded by the Reader to *additional levels*, using clicks (Fig. 2, horizontal dimension). The novice Reader, desirous of an "overview", can avoid the technical levels that are of interest to the expert, such as detail of experiments, and debates concerning the adequacy of proffered evidence. A more advanced Reader can "drill down" to find material of interest. This MultiLevel Format is **a powerful tool for any Reader**, who can first see an overall structure, and then take a path down into the material to a level that is best for *that particular Reader*, *at that particular time*. {33}

The **Assertions-Section** contains a *List* of Assertions, *i.e.*, statements considered to be "generally believed" and/or "well-established". For a *given* Assertion, the Reader can, by just a click, see the Evidence for (and against) the Assertion, critically evaluated. By another click, descriptions of new research methods that may provide new Evidence can be viewed. In this way the Reader can “drill down” into the MultiLevel material, according to the depth of interest *at that time*. *NB*: The MultiLevel Format **does not exist in present review articles**. {34}

By containing only Assertions and their Evidence, the overall "structure" of the field is made apparent. Assertions need to evaluated based on the strength of the evidence that supports them. The most important Assertions are based on the best evidence and they provide the strongest "structure". Weak assertions are better placed in the Conjectures Section, so that the weaknesses can be explicitly stated, and a possible route to better evidence can be delineated. {35}

"One size *may not* fit all." In the case of the Assertions-Section, the Consolidator may find that a further classification is needed for the material submitted. For example, topics that are in contention could be subdivided into "Conventional Assertions" and "Unconventional Assertions". Such subdivisions may be suggested by Readers or Contributors. The goal of the Consolidator should be the best presentation of the given topic, and some experimentation may be necessary to find the best organization. Indeed, different organizations of Knowledge could be the basis of the use of newer Formats in some topic-areas. {36}

The **Conjectures-Section** will contain a *List* of statements (written in the form of Assertions) within the purview of the Narrow-Topic of the Compendium, but having an



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inadequate experimental basis to be considered an Assertion. By clicks, the Reader can expand the text to include the reasons that support or refute a given Conjecture, while further clicks can reveal possible experimental methods that might prove or refute that Conjecture. {37}

The Conjectures-Section (which **does not exist in present review articles**) can contain contributions from those scholars who do not have the time and/or resources to pursue an idea, even a good idea. Such scholars include Emeritus Professors, Investigators whose grant applications were not funded (80% of applications!), "post-docs" working outside of their original fields, researchers who have ideas (but for one reason or another, do not have facilities or support to test them), or those who (though having research training) work in institutions or at jobs where research is not possible. The Chained-Hash-Algorithm (described later) will ensure that anyone submitting a Conjecture that is published online in an AEC-Compendium-Forum can receive proper credit, even if the words or ideas are later plagiarized. Because of this automatic protection, submitting ideas to a Conjectures Section is actually *desirable* from the Author's standpoint, in order *to establish priority about the idea.* This is similar to the effect of preprint publications today, but without the requirement for data to qualify as a preprint. {38}

The Conjectures Section is important because informed conjectures may provide a basis from which new advances can occur, as has occurred repeatedly in the history of science. The Section may also contain hints of the benefits and problems of different experimental paths that may be of use to those who may want to work on a Conjecture. {39}

It is expected that the *placement* of a given entry in an AEC-Compendium-Forum will be *dynamic*. A given statement may start as a Conjecture and later be moved into the Assertions Section (or *vice versa*), as the evidence builds, over time. {40}

The **Stronger-Inference Section** will have a *List* of Observations that, by present Knowledge, are not understood. (Again, this **does not exist in present** review articles.) **Note:** here one does ***not*** *start with a hypothesis*, even though popular descriptions of science state that a hypothesis is the starting point of a scientific study. The reason to ***not*** *start with a hypothesis* is described in a wonderfully honest, insightful quote from T.C. Chamberlin, a geologist, who, in *1897*, said [Chamberlin1897] [slight editing shown by brackets]:



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> "The moment one has offered an original explanation for a phenomenon [and the explanation] seems satisfactory, ... [At] that moment affection for [one's] intellectual child springs into existence, ... and as the explanation grows into a definite theory [one's] parental affections cluster about [the] offspring and [the theory] grows more and more [valuable and indispensable] ... .
>
> "There springs up also unwittingly a pressing of the theory to make it fit the facts and a pressing of the facts to make them fit the theory…." {41}

To avoid this (otherwise inescapable) trap, the Author [Jewett2005] has recommended "Strong***er*** Inference" which *starts* with an ***observation*** *that has not yet been understood.* This must be followed by enumeration of ***all alternative hypotheses*** that might account for the observation, based on present knowledge. Then, using observations, *hypotheses are rejected by experimentation.* The skill of the scientist is evident by the number of hypotheses a given experiment can rule-out. The process continues until a single hypothesis remains that has survived an experimental test by which it could have been rejected. This remaining Hypothesis is the "currently-held view" of the "cause" of the Observation (and so could become an Assertion in a Compendium). {42}

To the laity, this remaining hypothesis is "truth," but the Scientist knows that this currently-held view can change if new Knowledge offers new Hypotheses. If so, then one must return to Experimentation in order to rule-out the new Hypotheses. {43}

It is commonly stated that one can "only disprove a hypothesis", one can never "prove one". This depends on the hypothesis. If the hypothesis is a broad generalization ("All swans are white"), then it can only be disproven. On the other hand, if the hypothesis is limited ("The group of swans in this pond sometimes includes a black swan"), then the hypothesis *can* be proven. This difference is especially important in Medicine, where the hypothesis is often limited ("this patient has tuberculosis"), and the diagnosis can be proven by a single test (*e.g.,* sputum analysis). {44}

An *Important Note*: In Medicine, a "Differential Diagnosis" is formulated just like Strong***er*** Inference!

1. In documenting a patient's medical condition, first, the physician describes a "chief complaint" (an Observation chosen from the patient's history as important).



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2. After a detailed History (containing Observational evidence), the physician lists the clinical and laboratory findings (Evidence).
3. The clinician must next list the *Differential Diagnosis,* a list of *all* diseases (hypotheses) that might explain the chief complaint and observations.
4. Finally, there should be a list of further tests (Experiments) still needed to rule out (or rule in) some of the diagnoses. The skill of the clinician is shown by proposing tests (independent, experimental observations) that will rule out as many diseases as possible. {45}

*The significance of this parallel between Differential Diagnosis and Strong**er** Inference is that Medical School Faculty can compare a* Clinician's use of Differential Diagnosis with that of the Scientist using Strong***er*** Inference. In this way, **the use of Strong*er* Inference within AEC-Forums for improving Medical Knowledge** can become part of Medical and Surgical Post-Graduate Education. {46}

The aphorism "Strong***er*** Inference sharpens the cutting edge of science" will be demonstrated as it is being used in AEC-Compendia. By having Strong**er** Inference as a part of AEC-Compendia, it becomes a natural part of the Consolidator's thinking while developing an AEC-Forum. This is one of the ways that AEC-Forums (and their associated AEC-Compendia) can make an important contribution to Post-Graduate Education in *both* Science *and* Medicine. {47}

**Node.3 Variations on the MultiLevel-Format**

Note that the MultiLevel Format is applicable ***to many different overall teaching patterns***, including many in Medicine, as shown in Fig. 3. Thus, should some Consolidator find that MultiLevel Format described above does not suit what is needed for some Narrow-Topic, a change in the meanings of the sections or levels may make the Format useful. What is *most important* is that the presentation be useful to the contributing experts, as well as the ultimate Readers. {48}

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Fig. 3: The large variety of different expansions that can be used in a MultiLevel Format.

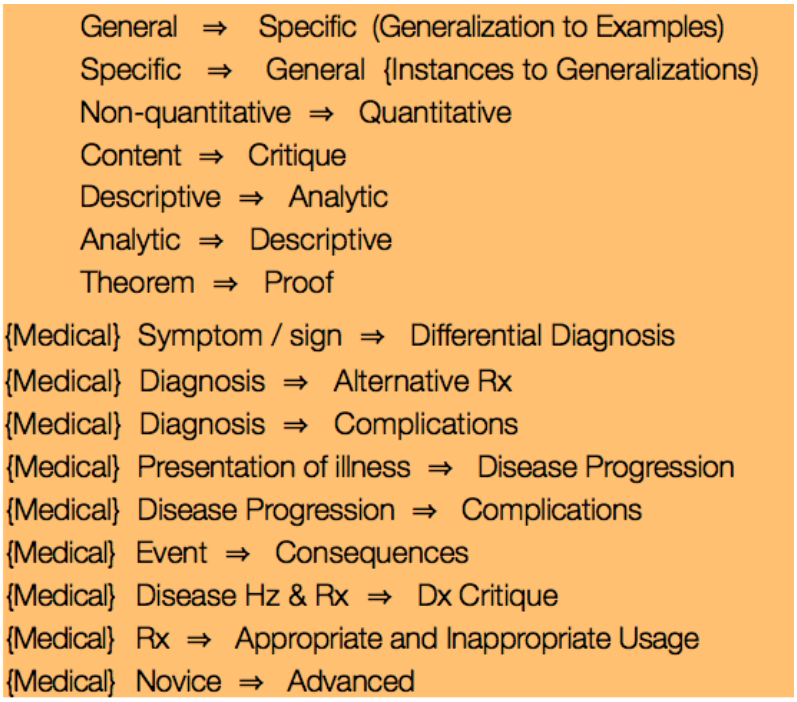


Fig. 3 Legend: The MultiLevel Format is applicable to many teaching situations. The list here is not exhaustive, but intended to show the large range of applicability of the MultiLevel Format. {49}

**Node.4 The MultiLevel-Format as an aid to writing**

A previous idea needs further explanation and expansion. Near the start of Node.2 (top of p.14) is the statement:

"The design of the Compendium-Format has ***two mutually-reinforcing*** goals:

1. To be ***easy to create*** (by concentrating on the basic "structure", *i.e.*, the core ideas of the Narrow-Topic; and by organizing the presentation in a MultiLevel Format)."
2) To be ***easy to comprehend*** (by the simplification derived from concentrating on the basic "structure", and by using the MultiLevel Format). {50}

*With respect to #1*: The process of writing in a MultiLevel-Format is very similar to, and has the strengths of, the method of "writing a paragraph", as is commonly taught in high schools and colleges (here paraphrased): "At first, tell them what you will tell



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them; then tell them; and at the end, tell them what you told them." Paragraphs in this form are *easier for the Reader* for the same reasons that we have presented for the MultiLevel Format. What this does *for the Author* is force an organization onto the presentation in which the "summary (thesis) sentence" is the first Sentence the Reader sees in the paragraph. In order for the Author to compose such a first-Sentence, the Author must mentally go through the *contentions* that will be presented, and summarize them in his/her mind. That summary becomes the first Sentence. *This thought-process ensures that the **goal** of the paragraph is clear to **both** the **Author** and the **Reader.*** This same procedure is *an essential part of writing in a MultiLevel Format.* {51}

What the MultiLevel Format *adds* for the Author is the ability to easily categorize the "contentions" into Levels, and indicate those Levels to the Reader. As described by Jewett [1981] in his article on "Multi-level writing in theory and practice", a standard presentation is ***linear***, requiring **every** Reader to follow the *same path* through the material. *Any material that is **secondary*** to the main theme will tend to *interrupt the linear flow of the ideas*. In a linear-presentation-mode, considerable author-time is devoted to finding a way, within the linear-text, to express the importance of this ***secondary material***. The Author tries out many phrases, such as "However, . . ", "On the contrary,…", "Another view …", "Despite …", *etc*. In contrast, the MultiLevel Format has a ***parallel*** presentation, where the Reader can immediately understand that the ***secondary material is secondary,*** by means of the typographical method chosen by the author to indicate different levels. So, the author can easily add secondary material just by shifting that material to a different level-- and writing is thus faster and easier. {52}

The ease of writing in an MultiLevel Format was confirmed when Jewett & Rayner wrote an entire textbook in this style: "Basic Concepts of Neuronal Function" [Jewett1984]. Both authors, each very experienced in technical writing, found it ***much easier*** to write in this format. {53}

### Node.5 The MultiLevel-Format mimics the Knowledge-Path

Returning, now to the 2nd part of the statement near the start of Node.2 (top of p.14):

"The design of the Compendium-Format has ***two mutually-reinforcing*** goals:

1. ...



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2) To be *easy to comprehend* (by the simplification derived from concentrating on the basic "structure", and by using the MultiLevel Format).

The reason that the MultiLevel-Format aids comprehension is shown in Fig. 4. In Fig. 4 the multiplicative nature of the MultiLevel Format is diagrammed, as explained in the Legend. {54}

Fig. 4: The multiplicative nature of MultiLevels in AEC-Compendia.

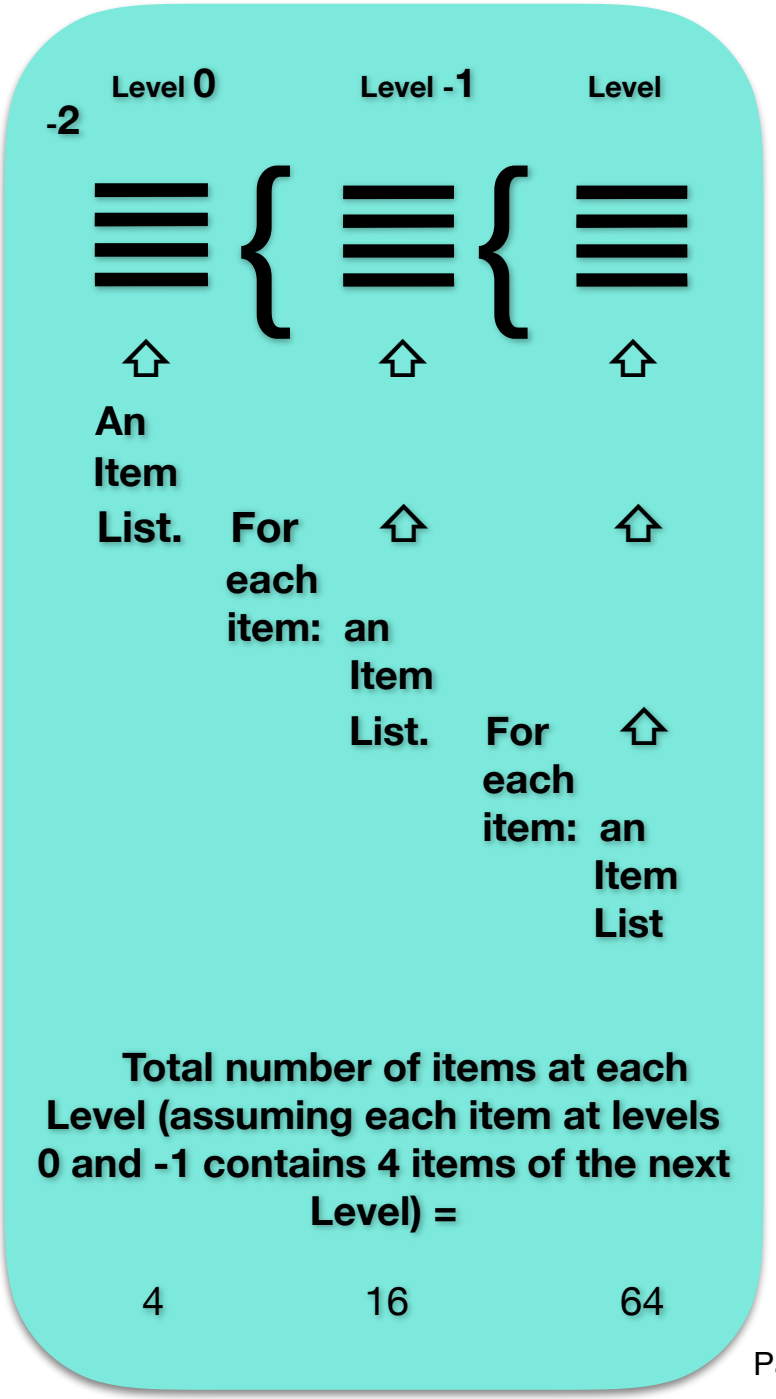




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Fig. 4 Legend: This diagram demonstrates what is *not* shown in Fig. 2: that the increasing Levels of the MultiLevel Format are multiplicative in number. That is, more and more *detail* is described when moving to the next lower level (more negative level number). {55}

In Fig. 4, the horizontal lines show *items* at three levels, *within a single Section,* such as "Assertions". For didactic purposes, let's assume that there are four Assertions (shown just as horizontal lines at Level 0). Further, assume that the third Assertion contains four items (as indicated by the large '{' symbol). In turn, the third item at Level -1, itself contains four items at Level -2. When this sort of expansion occurs for *many* of the items of the Assertions Section, then the ***total number of items at*** *each Level increases as a multiple of the preceding Level* (as shown by the numbers at the bottom of the Figure). Notice also that the amount of *detail increases* when going to more negative Level numbers. {56}

Expressed differently, the evidence needed for an Assertion at Level 0 is made up of greater and greater ***detail*** at Levels -1 and -2, *etc*. {57}

Thus, when going from **RIGHT-*to-left*** in Fig. 4, one is moving in the *same direction as "up" on the Knowledge-Path in Fig. 1 with respect to increasing generality and decreasing particularity.* {58}

That is, when the MultiLevel Format is used in a Knowledge-Step, *the relationships **within each** Knowledge-Step* is analogous to the relationships of the Steps to the Knowledge-Path itself. Stated again in different form: the *local* organization in each Knowledge-Step mimics the structure of the *more-global* Knowledge-Path of Fig. 1.

The goal of the Knowledge-Path, going from particularity to generality is the same goal as that for *within* a Step, where the Level 0 generality is based on the particularities in lower Levels. W*ithin a step, each Assertion is* essentially an accurate *summary* of the material at lower-levels within that Step, just as a "higher-level" AEC-Compendium (in Fig. 1) should accurately summarize the Knowledge of "lower-level" AEC-Compendia. {59}

The reason that this organization makes it "*easy to comprehend*" should now be clearer. A Reader of an AEC-Compendium will find the "summary statements" first, and does not need to go to lower levels, except when there is a desire to "dig deeper" *on the Reader's part.*

*For the same reason, it is easier for the Knowledge-Consolidator of a Knowledge-Step to evaluate how the Knowledge in previous steps will be incorporated (or modified) to go*



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*into the Step the Consolidator is creating.* {60}

In summary, the overall goal of AEC-Compendia is to organize information and knowledge so that it is easily accessible and understandable. The Knowledge-Path represents such organization in that the generality of ***knowledge-structure is created as the particularity of detail diminishes.*** The same organization occurs also *within* each Knowledge-Step *via* the MultiLevel Format. ***Knowledge-Path.*** {61}

### Node.6 How AEC-Compendia will be created

Forums, Blogs, and Wikis are well-developed on the Web, and AEC-Forums share *some* of their characteristics. However, AEC-Forums *must differ in significant ways* from each (as will become evident with further description). As a consequence, *new software is needed for AEC-Forums*. {62}

To start an AEC-Compendium-Forum, a self-nominated Consolidator establishes a WebSite with the Open-Source AEC-Forum software developed in this Project. The Consolidator chooses a narrow Topic for the AEC-Compendium-Forum. The Topic should meet the following criteria:

1. The Consolidator is interested in the Topic and will personally gain from creation of a Compendium on the Topic.
2. The Topic is ***very narrow*** in scope. A narrow Scope keeps the focus of the comments and content of the AEC-Forum within a range that one person's learning can encompass. The Scope can easily be enlarged ***later***, but It is very difficult to narrow a Scope, once an AEC-Forum has become established within a community of scholars.
3. The Topic has currency within Scholars of the subject-area, or will develop new interest by means of the AEC-Forum. {63}

The AEC-Forum-Software for an independent WebSite will be Open-Source and will be freely available on the Web. The Consolidator can place the WebSite on the Web either by means of an Institutional Server, or by a Hosting Service subscription (as described later in the Competing Interests Section of this Article). To start, the only Information the Consolidator must input into the start-up text boxes of the Software, are these items:

1. Title of Compendium
2. Subtitle (if any)



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3. Consolidator's name
4. Consolidator's affiliations
5. Keywords
6. The Narrow-Topic of the Compendium
7. Consolidator's email address
8. SiteAdmin's email address
9. Editor's email address (if appointed)
10. URL of this AEC-Compendium-Forum
11. Language, primary
12. Review checklist of MetaData required from Contributors
13. Review checklist of Search-engines to be notified about changes {64}

When the SetUp is complete, the AEC-Forum Software sends the Title, Subtitle, and Keywords to all online search-engines that were chosen by the Consolidator. The Consolidator abstracts from the available literature (or an unfunded grant application) some entries for the different sections of the AEC-Compendium-Forum, and emails Authors who have published material relevant to the AEC-Forum's Topic, informing them that their work is being quoted. It is highly likely that the quoted Authors will reply with corrections and/or additions (see Node.10, below). {65}

**Node.7 The Rules and Features of AEC-Forums**

An AEC-Forum operates under the follow ***Rules****:*

1. The *entire WebSite* can be **read** by anyone, without restriction (Open-Access).
2. All submissions are posted under a Creative Commons License that is specified on the WebSite and specifically agreed to by each Contributor during Registration.
3. Copying of the AEC-Forum's content is only possible for Registered Users. All MetaData associated with the parts copied *must also be received and stored* by the (copying) Registered User. Thus, any material can be quoted with correct attribution from the MetaData. The MetaData will contain the content and hashes of the associated Chained-Hash-Algorithm. If a User who is *not* registered tries to highlight and copy the content of the WebSite *without the MetaData*, the WebSite's Software will make that very difficult.
4. The SiteAdmin can be contacted by any User, without any registration required (in case an unregistered Reader finds a problem).
5. Submissions are accepted only from Registered Users (email verification required)



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who use their own names and have also provided requested MetaData that will be saved in association with every Submission by the User. In a rare instance, an exception to this rule can be made by the Consolidator, with appropriate justification; the communications regarding these exceptions are not saved by the system, but are listed by date in the History, as "User Exceptions, Reviewed and Accepted".

6. The Consolidator is solely responsible for placement in the AEC-Forum of every submission received. This activity can be assigned to the Editor by the Consolidator.
7. There are six Sections within the AEC-Forum, to which a submission may be placed, by the Consolidator/Editor (with or without comments added):
   1) Assertions
   2) Conjectures
   3) Observations for Stronger Inference
   4) Rejected Submissions
   5) Scientific Comments (general)
   6) Public Comments.

   This list may be changed at the discretion of the Consolidator, as needed to best fit the needs of the Narrow-Topic.
8. Web Search-Engines, specified by the Consolidator, will be automatically notified whenever new submissions larger than a specified size are placed within a Section. This provides a means for new Readers to find the AEC-Forum from word and phrase matches.
9. Specific Comments about a Submission, from the Consolidator and/or other Readers, are placed in an Extension of the Submission's primary location.
10. **All** submissions to the AEC-Forum WebSite **are saved, unchanged**, in the History of the WebSite (automatic by modified Version Control Software). This protects the Consolidator from accusations that bias has affected either the editing or the placement of the submission within the WebSite. The only exceptions are for inappropriate, vulgar language that can be redacted before being placed in "Rejected Submissions". Submission communications are accessed by links available with the submission.
11. All submissions are processed by the CHA (ChainedHashAlgorithm) and the appropriate content and hashes are stored with the MetaData associated with the submission. {66}



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The following are some additional ***features*** of the AEC-Forum Software:

1. The Software registers possible Contributors, with email-address confirmation.
2. The Software automatically handles routine communications, using the email addresses provided by the Consolidator.
3. The Software acquires and makes available to the Consolidator, Editor, and SiteAdmin statistics on usage, origin of non-registered Readers, error messages, *etc.*
4. Changes to the code of the Open-Source Content Management System (TikiWiki) can only be made after the SiteAdmin has signed off having read the warnings concerning the possible adverse effects of changes.
5. All communications within the MetaLink-Protocol are automatic (see Links, later). Each Reader can choose the formatting of the SortableTable, and save the choices as cookies (see Links, later).
6. Presentation of content is uniform across AEC-Compendia unless the Consolidator finds a need for additional features. The options available to the Reader, and how to control the options, are also uniform across AEC-Compendia. This makes it easy for the Reader, once accustomed to the format, to access different paths easily.
7. The Software is compatible with existing Browsers and Word Processors.
8. Use of the Software is intuitive, and does not require use of Manuals, or extensive Help. {67}

**Node.8 Who will be Consolidators for AEC-Forums?**

As evident above, the duties of the Consolidator are several. Whom in Academe can we count on? Who will self-nominate for this activity when there are *always* grant deadlines and teaching responsibilities? {68}

This Article supports a view of Post-Graduate Education based on the following aphorism:

A goal of "Training" is for the student to
"Learn specific responses for specific situations".
A goal of "Education" is for the student to
"Learn to devise new responses for new situations".
A goal of "Post-Graduate Education" is for the student to
"Learn how to Create Knowledge, ***by doing it***". {69}



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The best candidates for Consolidators are **Post-Graduate Students *at all levels.*** There are several reasons for this statement:

1. These students are organizing information and knowledge *for themselves,* as part of the process of qualifying for a higher degree, or for a higher academic position.
2. These students have Thesis Advisors who can help them in their efforts to AEC-Compend a narrow topic.
3. These students will want to coordinate the *self-organizing community of like-minded scholars interested in the same* narrow *topic that will automatically occur as the AEC-Forum becomes known*. Such scholars have similar interests, may become friends and collaborators, and *may become sources of jobs* in the future. The community will be world-wide and not limited by the requirement to meet other scholars at expensive international meetings.
4. These students have grown up with computers, and with social networks based on computers, so AEC-Forums are just another part of their "computerized" life.
5. The bibliography resulting from a good Compendium could be a major part of the bibliography that is needed for a thesis.
6. It is a unique opportunity to have one's research plans *peer-reviewed* both before and during the research.
7. It may provide a chance to "make a mark" in a field. The discussion (over which the Consolidator has some control) can allow the Consolidator to demonstrate competence by (offline) analysis of issues and publications.
8. AEC-Compendia may be listable on a *C.V.* in the future, if the Compendia are of good quality. {70}

Specifically, what students are we talking about?

1. Pre-doctoral students studying for a Ph.D. in science, engineering, medical sciences, *etc*. These are Post-Graduate Students from a university's viewpoint.
2. Post-doctoral students entering a field that differs from that in which they received their doctorate.
3. Post-MD students in Medical or Surgical Residencies.
4. Post-Residency Fellows in Medical or Surgical Specialties {71}

The numbers of students in these categories are *large*. Here are some estimates:

1. Ph.D. students: The NSF (National Science Foundation) in April, 2015 listed total graduate students in Science & Engineering (excluding health) in the U.S. at over



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500,000, with about 140,000 in their first year [NSF2015]. If we assume that 15,000 drop out, and an average duration of 4 years, there would be about 125,000 new students per year. Since 50% of all students are above average, let's assume a number of 62,500 above-averaged Ph.D. students each year.

2. Post-Doctoral students: NSF listed over 40,000 postdocs in [NSF2015]. There is no estimate of the duration of the PostDocs. If we assume a 4 year duration, there would be 10,000 new PostDocs per year (all above average since continuing for a Post-Doc is *not* average).
3. Post-MD's in Residencies: The AAMC (American Association of Medical Colleges) estimated in 2013 the total physicians in Residency positions was over 116,000, with 28,500 in 1st year (average duration of 4.1 years) [AAMC2015]. It is common at many Medical Schools for Senior Residents to provide a Seminar on an advanced topic at least once in the Residency; regrettably this work is rarely published, even though many are considered by the faculty to be of high quality. Assuming that (the above-average) 50% of the Senior Residents were Consolidators, then there would be 14,500 AEC-Forums in this group.
4. The total number of above-average possible AEC-Compendium-Forum Consolidators in the above three groups is **87,000** *per year* (62,500 + 10,000 + 14,500). {72}

What has *not* been estimated in the number above are the following:

1. The number of students in any of the categories who study *outside of the U.S.* Science is international in scope and geography. Good students in other countries will AEC-Compend for the same reasons as U.S. students.
2. Scholars with research experience but who are not presently active in research, such as Emeritus Professors, Investigators whose grant applications were not funded (80% of applications!), and those, though having research training, are working where research is not possible. No numbers have been included for these possible Consolidators. {73}

If we allow a number of 13,000 to cover the last two categories, an order-of-magnitude estimate for the total number of AEC-Forums *per* ***year*** when each Consolidator creates only one Compendium, could be **100,000,** which is about 274 per *day*. While this is a large number, it is dwarfed by the estimate of **3,700** peer-reviewed **articles** that were published ***each day*** in 2006 (1,350,000 per year) [Bjork2009]. {74}

There is plenty of material for Compending, for all!



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### Node.9 How will Post-Graduate Students communicate with Experts?

The neophyte Consolidator need not fear that her/his expertise is insufficient for the job. Consider these reasons:

1. In reality, the Editor of a Journal does not know everything about which the Journal accepts articles. The Editor depends on his/her Reviewers for expert opinion, while the Editor *need only be able to read and understand* ***the reviewers comments, but not the exact details.***

   Similarly, the Consolidator of an AEC-Forum, in order to be effective, need only have a general understanding of the materials submitted. But this will be sufficient to deal with comments from a Contributing Expert. If mistakes are made, the Experts and Readers will bring them to the attention of the Consolidator; this is the method by which "peer review" can improve publications.
2. The Consolidator who is still in training will have available for advice a Mentor, either a PhD Thesis-Advisor, a Project supervisor, or a Senior Clinician. These Mentors will want each Compendium be of high quality, since it comes from their lab or institution. Consequently, they are likely to look carefully at what the Consolidator does.
3. The non-expert Consolidator can start a Compendium by doing a literature search and then quoting from the literature. The Consolidator need not express an opinion, but rather, can let others speak. In this way, it is the quoted author who "makes a claim", not the Consolidator. For example, imagine that the Consolidator finds this quote in the literature: "Experiment Q by Dr. R has not resolved this issue." This can be put into the AEC-Forum, and if others disagree, then the arguments will also make the AEC-Forum an interesting WebSite. Indeed, the Consolidator can write to Dr. R and say "I'm creating a Compendium related to your work, and I've found this quotation. Would you care to comment?" The probability of receiving a reply is *very* high (see Node. 10). The Expert's reply can go into the AEC-Forum. In this way, the Compendium can be built up, even by a neophyte Consolidator. {75}

### Node.10 Will experts review and contribute to AEC-Forums?

It is reasonable to be concerned about how much time academic faculty will be willing to spend on "yet-another job", busy as they are both writing grants and teaching.



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However, *self-interest is a powerful motivator:*

1. The Expert wants to be sure that her/his work is *quoted correctly*.
2. The Expert wants to ensure that *limitations in the work of others is described accurately and completely.*
3. The Expert wants to *increase readership* of his/her work. Citations in AEC-Forums and AEC-Compendia to the Expert's publications will collect new Readers. Any Citations to AEC-Forums and AEC-Compendia from the Expert's articles will create MetaLinks to the CitING publications (see Section 2, below).
4. The Expert wants to *increase the quantity* of what the Expert has "given away". Academia is a "Gift-Culture" where prestige is determined by the quantity and quality of what is given away (such as time, energy, and creativity) [Raymond2000]. Note that the recognition of the Compendium-Submission is by the *group of like-minded* scholars who have been automatically assembled during the AEC-Compendium-Forum-Process. Lack of participation may be noted as easily as participation.
5. The review of an AEC-Compendium-Forum by like-minded scholars is a form of *post-hoc peer-review.* It can be more detailed that the pre-hoc peer-review. Experts will be encouraged to provide skilled, helpful reviews because the Expert's "peer-review" comments or additions *are read and judged by their own Peers!* Such "Meta-PeerReview" does not occur in the paper-publishing paradigm (a major failing because of the [growing?] misuse of confidentiality).
6. The Expert *wants to be* ***quoted,*** but *not* to be ***plagiarized***. The CreativeCommons basis of AEC-Compendia encourage quotation, but do not guard against plagiarism. However, the AEC-Compendium-Forum's regular use of the Chained-Hash-Algorithm means that the correct authorship of the Expert's statements can be established and maintained (and by the nature of the Chained-Hash Algorith, the plagiarist cannot deny the plagiarism). The algorithm is described in Node.12 (below). {76}

**Node.11 What will ensure the quality of AEC-Compendia?**

There are a number of factors that should *sustain the quality* of AEC-Compendia, even though there is no central *control*:

1. The Consolidator's reputation will be affected by the quality of moderated AEC-Forums. This means that there should be strong motivation for the Consolidator to do a good job.



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2. Since all Submissions are automatically saved, any critical comments will need to be dealt with in some way, thus increasing the quality if the criticisms are useful.
3. If AEC-Compendia of poor quality appear, a WebSite running the Open-Source Software "SlashDot" can be used to provide Readers with evaluations of AEC-Compendia so that lower-quality AEC-Compendia can be avoided. SlashDot is a well-developed method by which evaluations by many "reviewers" can be organized and presented, and where *the reviewers themselves are rated for quality*. Automatic Meta-PeerReview *via* the Web!
4. Recognize that even a low-quality AEC-Compendia may be better than *nothing*. So, time spent in finding that a Compendium is not useful, may not be fully wasted; a few new References may be found.
5. Since AEC-Compendia can be copied (with correct attribution), it is feasible, under an extreme situation, to copy an existing Compendium, make changes that are felt necessary (with new attribution of the changes added to the prior attributions), and to place the modified Compendium on the Web in a new AEC-Forum. This offers a path for those who have considerable disagreements with a given Compendium (*e.g.,* when the Consolidator hinders or prevents contrary views in discussion). Note that copying and re-publishing a Compendium will be plagiarism if the original Compendium is not given correct attribution, as can be proven by the ChainedHashAlgorithm (Node.12, next). Such "forking" is common in software projects involving many volunteers, and does not stop collaborations.
6. A feedback mechanism similar to the one that improves and modifies MetaLinks (see Link.9, below) will also improve AEC-Forums and AEC-Compendia, as new Users and Programmers find ways to make the system better by adding to the Open-Source Software. {77}

**Node.12 Protecting submissions posted on AEC-Forums from plagiarism**

Authors wish to be quoted, but *not* plagiarized. The difference between quotation and plagiarism is in the attribution: is it correct or faked? A Chained Hash Algorithm can be used to establish which of two sources was first to publish on the Web, and also provides data that cannot be refuted by a plagiarizer. {78}

Providing proof of authorship could be especially important in the "Conjectures" category of AEC-Compendia. Conjectures do not have sufficient evidence in their favor, and



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may well be rejected in a paper-based publication-paradigm for that reason. Those who have such Conjectures are Senior Scientists or Clinicians, and Students just entering Post-Graduate Training, **and** everyone **in between!** These ideas are hidden because **if they are made public, the attribution will be lost** (*i.e.,* it is highly-likely that plagiarism may occur on the good ideas). By offering a place where attribution will **not** be lost, AEC-Forums provide a means for **broader dissemination of "odd-ball" ideas, and hunches**. Realize that **some of these ideas and hunches will actually become the basis for progress in the field**, as shown repeatedly in the history of science! {79}

There should be several classes of recognition when new evidence brings about a change of knowledge in a field:

1. Who thought of the idea, and when?
2. Who invented the method used to test and prove an idea, and when?
3. Who created the definitive evidence, and when? {80}

All of these scholars deserve credit for the ultimate result, though presently only #3 "counts". The use of a Chained Hash Algorithm in AEC-Compendia could certainly provide appropriate credit within the research enterprise, while contributing to dissemination of potentially useful, but yet unproven ideas. {81}

Here is how the CHA (ChainedHashAlgorithm) will work. A new contribution to an AEC-Forum (such as a comment, an annotated citation, a quotation, a section, *etc*.) is only permitted for those who have previously registered and provided name, contact information, and other MetaData, and have been verified by email. Automatic processing of a new contribution from a registered Author includes creating MetaData that identifies the Contributor as the Author of the contribution. Then, both the contribution and specified parts of the MetaData are concatenated together with a previously-chained hash number, and the whole concatenation is then hashed yielding the CHA Hash for that contribution. This is a variant of "cipher block chaining" [Schneier1996, p.193]. {82}

A characteristic of such Hashes is that change of even a single bit in the concatenation will change the Hash Number. While collisions (identical hash-numbers) can occur, they are *exceptionally unlikely, especially when the change* in the contents of the concatenation *is limited by actual names, and appropriate words of a known language.* Further, any claim of a plagiarist to have published the contribution before the true Author can be rebutted by review of the published hash-numbers of both the Author



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and the plagiarist. {83}

Since any errors in these hash-numbers might have a serious effect on an Author's career, mistakes (such as data-drop out) could be costly. Therefore, extra ECC (Error-Correcting-Code) is applied to the hash-numbers for transmission and storage. The ECC Hash-Numbers are stored with the AEC-Compendium-Forum's MetaData, and transmitted to MetaLinked WebSites with MetaData exchanges in the MetaLink-Protocol. {84}

**Node.13 A Summary of the differences between publishing a Review Article with present-day paper-based methods, compared with posting a MultiLevel-AEC-Compendium**

Fig. 5: Comparison of different ways to publish a *Review Article (on* ***four pages).*** {85}

| **Comparisons of ⇒ ⇒ with respect to ⇓ ⇓** | **Paper-based Journal** | **Online Journal** | **Individual AEC-Compendium, with MetaLinks (displaying MetaData in SortableTables)** |
|---|---|---|---|
| **Paradigm shift** | No | No | **Yes**: both AEC-Compendia & MetaLinks |
| **Author's Academic Level** | Senior Scholar (Faculty, Scientists, & Clinicians) | Senior Scholar (Faculty, Scientists, & Clinicians) | *All Scholars*, both Senior Scholars (Faculty, Scientists, and Clinicians), and those in training (PostDoc, PreDoc, Clinical Fellow, Medical/Surgical Resident) |
| **Readership Limitations** | Must be Subscriber or Library user | None: Open Access | None: Open Access |
| **Reader's Cost** | High | Low | Low |
| **Author's Cost** | Low | Moderate | Low |
| **Typography by** | Publisher | Author | Author |



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| Comparisons of ⇒ ⇒ with respect to ⇓ ⇓ | Paper-based Journal | Online Journal | Individual AEC-Compendium, with MetaLinks (displaying MetaData in SortableTables) |
|---|---|---|---|
| **Facilities needed to make Review public** | Publisher, Subscribers & Libraries | Online Publisher; Fee support | Individual Scholar with access to WebSite server (Institutional [free] or Commercial [low fee]), using Open-Source Software for AEC-Forums, MetaLinks |
| **Peer review** | Once | Once | **Continuous**; *After* Posting |
| **Time before content is available** | Often Many Weeks from review, delays waiting for space | Possible reduced review delays; some waiting for space | **Immediate Posting**;<br>1. Peer review occurs after posting;<br>2. No waiting for space |
| **Can content expand with new info?** | No (separate errata only) | Yes, by Revision | **Yes.** And Links remain active and accurate even when material is deleted from display but still in "history" files. |
| **MultiLevel Format?** | No; *Linear* presentation | No; *Linear* presentation | Yes; **Parallel** format for a range of different Interests and/or Backgrounds |
| **Links** | Citation & Backlink only to entire Article; Separate WebSite for Backlink Compilation; *no Metadata.* | Links (and sometimes Backlinks) on WebSite with content; Links only to *start* of Article; *no Metadata.* | 1. **MetaLink-Metadata automatically available on same WebSite as content, in SortableTable;**<br>2. **Links are *sentence-to-sentence* with sentences marked in text;**<br>3. ***Metadata specific to each field* and adaptable to changing knowledge;**<br>4. **Author's rating of importance of the specific Link.** |



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| Comparisons of ⇒ ⇒ with respect to ⇓ ⇓ | Paper-based Journal | Online Journal | Individual AEC-Compendium, with MetaLinks (displaying MetaData in SortableTables) |
|---|---|---|---|
| **Efficiency for Developing a Bibliography** | *Low* efficiency; Must access multiple WebSites; Must choose Link-jump based only on standard citation to whole article | *Moderate* efficiency; Online; May need access to several WebSites; Must choose Link-jump based only on standard citation to whole article | **High** efficiency; All information available online with these reader-aids: 1. **Assertions with Evidence** 2. **Observations with Stronger-Inference alternative hypotheses** 3. **MultiLevel-Framework** 4. **MetaLinks** (marked in text) **with SortableTable-Metadata** (and cookies) 5. **Creative Commons copyright with correct attribution in Copy/Paste** 6. **Automatic Hashes against plagiarism.** |
| **Archive's Value** | Value **decreases** with time as *content* becomes out-of-date. | Value **increases** with time **only** if Backlinks present with the content on **same WebSite** | Value ***always increases*** *with time because of:* *1.* ***Automatic MetaLinks with Metadata in SortableTables*** 2. ***New Links marked in text on WebSite*** 3. **Extensive, appropriate Metadata** 4**. Fewer plagiarisms.** |



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| Comparisons of ⇒ ⇒ with respect to ⇓ ⇓ | Paper-based Journal | Online Journal | Individual AEC-Compendium, with MetaLinks (displaying MetaData in SortableTables) |
|---|---|---|---|
| **Ancillary benefits** | Author's reputation enhanced if Journal is highly ranked | Rapid Publication at times | *1.* ***Self-organizes*** **a community of like-minded scholars**<br>2. **Speeds knowledge creation**<br>3. **Actively teaches scholarly approach to problems in AEC-Forum topic**<br>4. **Each participant contributes based on motivation by *self-interest***<br>5. **Contributions (including Conjectures) with correct attributions, and protection against plagiarism**<br>6. **Helps to identify weak Assertions and additional research pathways**<br>7. **Framework helps subsequent consolidation in Knowledge-Path**<br>8. **Is "self-correcting" *via* continuous peer-review**<br>9. **Can be used to "make a mark" in one's field.** |

(no Fig. 5 legend)

### Node.14 The use of AEC-Forums for Preprint-Critiques

The AEC-Forum Software is designed for collection and display of *peer-reviews* of scholarly work by Consolidators. Another means of obtaining *peer-reviews* is a Preprint Publication on the Web. Such preprinting has a substantial history in Physics through the WebSite "ArXive". Pre-printing is just beginning in Biology and Computer Science *via* "PeerJ Preprints". If a Preprint is the content of an AEC-Forum, then the Forum-Software will post the Article, and receive comments from registered viewers. The Author/Consolidator can then reply, or modify the content, as appropriate. Thus, if the "peer-review needs" of scholars are not being met, then the AEC-Forum Software will provide an easy means for scholars to obtain peer-review on the Web. {87}



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An advantage of the AEC-Forum Software for use in Preprinting is that it provides protection against plagiarism (see Node.12). By this means the ChainedHashAlgorithm will provide definite evidence of the date of posting.

Another advantage is that the Software also provides automatic ForwardLink creation in the MetaLink-Protocol if there are Citations before the Article finds a permanent Web location (see Link.11). {88}

### Node.15 Speeding Publication on the Web-Based Knowledge-Repository via posting of Preprints

Just as the AEC-Forum Software can be used to post Preprints (see Node.14), the Software can also be use to *post Articles* on the Web. As with Preprints, the advantages include protection against plagiarism (see Node.12) and automatic ForwardLink creation (an Active Archive, see Link.11). {89}

Thus, an Author could post using the AEC-Forum Software initially for a Preprint-Critique, and then, after either replying to the Critiques or modifying the Article, the continued posting would essentially be a Web-based "publication" on an Active Archive, which can remain available until the Preprint becomes a Journal-Article, or until it is Archived elsewhere. {90}

Recognize that the extension of the AEC-Forum Software into "Preprints" and "Posting" provides *more tools to make the Web the Knowledge-Repository it should be*. {88}

MetaLink Software also facilitates delineation of Knowledge-Slices in such a Knowledge-Repository (see Link.13). {91}

### Node.16 The multiple roles of AEC-Forums in the careers of Post-Graduate Students

As described in this Article, AEC-Forums can play multiple roles in the careers of scholars.

1. Initially a Post-Graduate Student could use an AEC-Forum to help delineate an area of research that is promising for an Article or Thesis.
2. During the research, an AEC-Forum could help a Post-Graduate Student to obtain comments and advice from experts other than the student's thesis advisor.
3. As research results became available, the Post-Graduate Student could use an AEC-Forum to obtain Preprint-Critiques.
4. While waiting for acceptance from a Journal, an AEC-Forum can be a form of



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Open-Access "Publication" on the Web.

5. As an Academic Career develops, there will be repeated need for AEC-Forums to study new areas, or new aspects of an area, for publications and grant applications.
6. Each of these AEC-Forums provides the Consolidator with the opportunity to have two-way communications with Experts in the field. This is a personal advantage that is needed *throughout an academic career.* {92}

***Methods (continued):***

## Links:

The *second* major component of the Knowledge-Creation Tools are ***Links*** *between* Nodes.

### Link.1 Confusing Link Names

Present-day Link terminology is confusing for non-programmers, at best. As new uses and needs for Links are invented, as done here, *new terms are needed,* for these reasons:

1. The new Links have **many properties not available** in present Links; new Links should be clearly distinguishable from previous Links.
2. The new Link Names should not have been used previously.
3. The Link Names need to indicate ***functionality that is intuitive*** for **Readers** (see Fig. 6, next). {93}

Fig. 6: Comparing the New Names for WebLinks with presently-used Link Names.

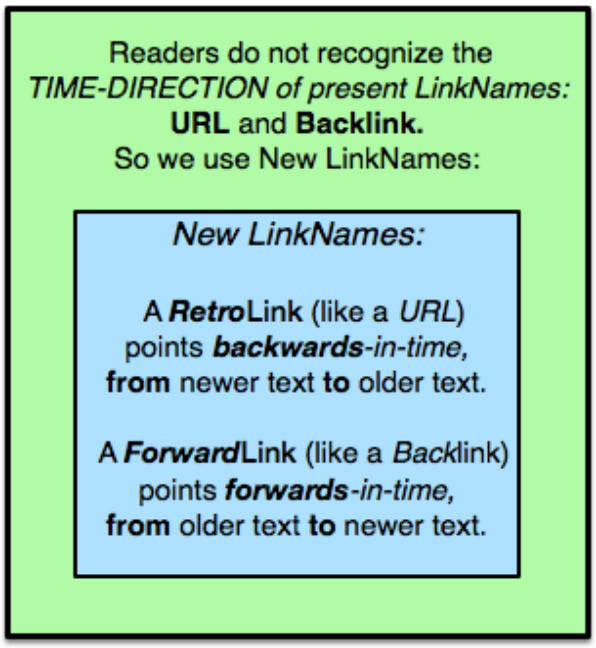




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Fig. 6 Legend. Some readers find it hard to realize that Backlinks and ***Forward***Links are the same, until they read the last line of this Figure. {94}

The Author's guess as to a reason for this terminology confusion, is this: A "Backlink" was probably named by programmers, from the programmer's point of view-- initially, a link can only go from newer-text to older-text (*e.g.*, as in a traditional citation). Hence, *another link* based on the initial link, now from the older-text to the newer-text, is going *back to the text* of the original citation (a BackLink). {95}

One way of remembering the *functional usefulness* of these Links, is as follows:

1. A RetroLink points **to** what **was** important.
2. A ForwardLink points **to** what **will be** important. {96}

**Link.2 Definitions, Link**

**MetaLink** = a Web***Link*** containing ***Meta***Data of interest to the Reader. MetaLink is a generic term that includes both ***Retro***Links and ***Forward***Links, *i.e.,* the *new Links* of the MetaLink-Protocol. (Since "meta" derives from "above" or "superior", this name also implies that MetaLinks are better than present WebLinks, which they are.)

**RetroLink** = A MetaLink in a Cit*ing* Newer-Text, that takes the Reader to the Cit*ed* Older-Text.

**ForwardLink** = A MetaLink in a Cit*ed* Older-Text, that takes the Reader to the Cit*ing* Newer-Text.

**LinkPair** = A pair of MetaLinks comprising a ***Retro***Link and a matching ***Forward***Link created from it. The Pair are created by the two WebSites that are conforming to the MetaLink-Protocol. The RetroLink is in the Cit*ing* Newer-Text, and the ForwardLink is in the Cit*ed* Older-Text. A "standard citation" is a RetroLink when using the MetaLink-Protocol.

**MetaLink-Protocol** = The Protocol that defines the actions needed from an Author and the two WebSites of a LinkPair. For a detailed description of MetaLinks, see the preprint of the MetaLink-Protocol [Jewett2016b].

**Slice of Knowledge** = a subset of Knowledge defined by the contents of all the articles/compendia/*etc*. within a MetaLink network connecting a primary source by its RetroLinks and the ForwardLinks it has acquired. Secondary Links in works linked to the primary source are ***not automatically*** included in the Slice. {97}



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### Link.3 The Reader's Subjective Time

The names "RetroLink" and "ForwardLink" are easily understood from the Reader's point of view because the names relate to ***the Reader's subjective time,*** which is ***the time of what is being read*** (*e.g.* see Fig. 7, next). {98}

Fig. 7: Objective time vs. the Reader's Subjective Time when reading TextB.

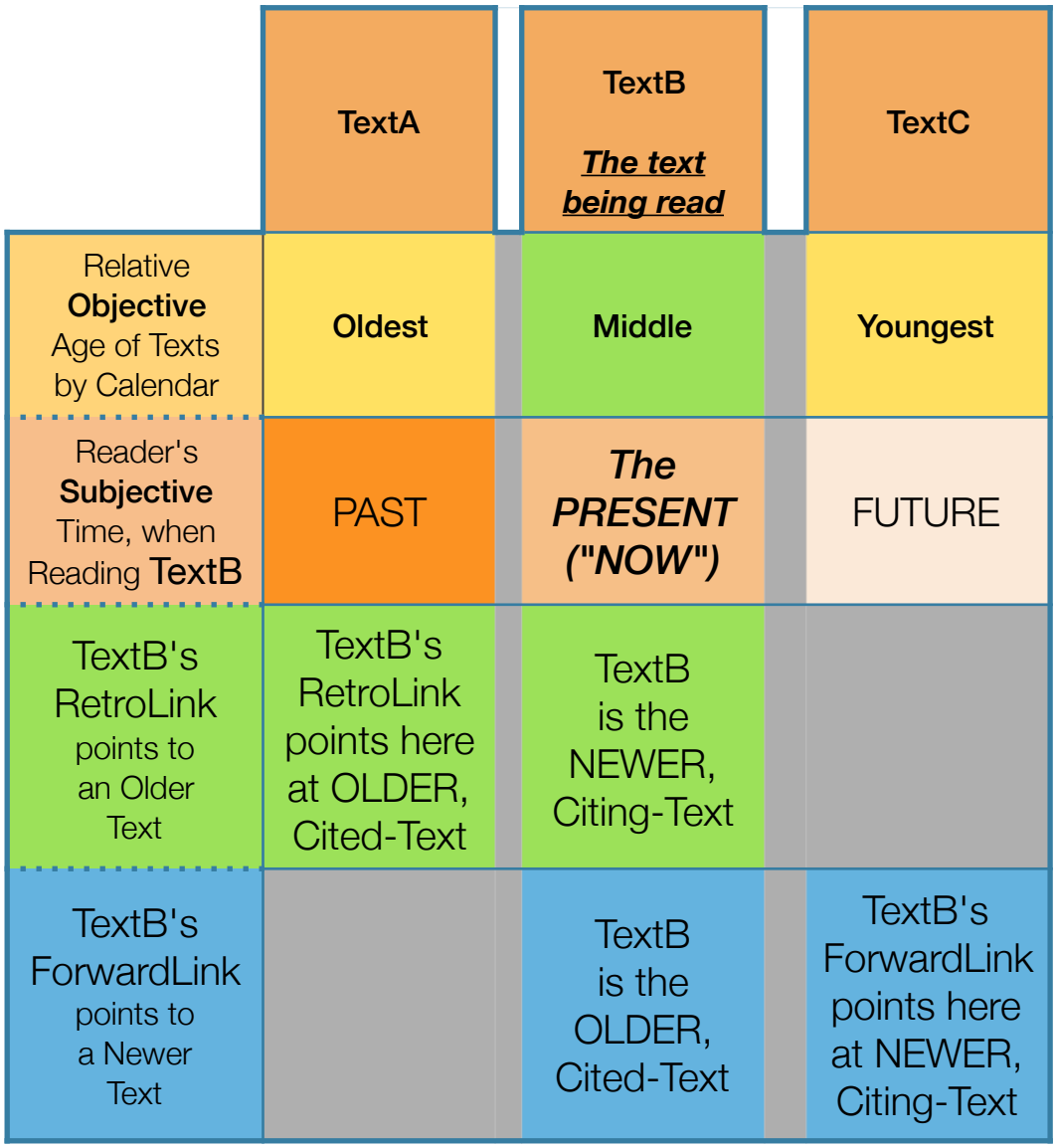


Fig. 7. Legend: The Reader's "Now" (Subjective Time) is determined by the material ***being read***, not by Objective Time. In the Reader's Subjective time *when reading TextB*, TextC is in the future and TextA is in the past. {99}

TextB is ***both*** the *Newer Text* (relative to Text A) ***and*** the *Older Text* (relative to TextC),



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**at the same time.** This can occur because the *relative* "age" is determined by the relationship with the *other* Text of a LinkPair, as shown in the two bottom rows, describing the RetroLink and ForwardLink. {100}

### Link.4 Why are new Link-Formats needed?

*Forward*Links are ***critically important for scholars*** for the following reasons (the reasons also apply to presently-available "Backlink" sources, such as the Web of Science):

1. A Reader can follow ***Forward***Links to *the more recent activity in the field*.
2. ***Forward***Links automatically demonstrate t*he contribution of older work to newer discoveries*.
3. ***Forward***Links are ***non-semantic***. ***Forward***Links are based on ideas, concepts, and associations occurring in the minds of *human experts*, in conditions where automatic indexing of words and phrases by machines ***may fail*** to find a connection! For example, the glossary of a Linking article may not share ***any words*** in common with the glossary of a Linked article, especially where the Citation has been across scientific fields; in such a case ***word-searches will be very unlikely to provide any means to find the "idea-linked" article.***
4. ***Forward***Links easily cut across disciplinary and keyword barriers.
5. The primary ForwardLinks, together with the RetroLinks, define a unique, automatically delineated "***slice of knowledge***" within the multi-dimensional, Web-Based Knowledge-Repository (see Link.13).
6. The ForwardLinks contain easily-accessed MetaData that are especially useful because the MetaData Content is specific to a given field, and influenced by the users of the MetaData (see Fig. 11). {101}

### Link.5 Problems with "Backlinks"

Unfortunately, there are *many* ***problems*** with present-day "Backlinks":

1. The Web of Science (previously Science Citation Index) is available online, but requires fees from Readers. Further, it does not index new publishers/WebSites [Larsen 2010]. Even though in 2008 Web of Science indexed over 1,187,000 articles (about 3,250 articles ***per day)*** [Michels2012], in 2007 it was covering "a decreasing part of the traditional scientific literature" [Larsen2010]. Larsen also stated: "A special report from NSF in 2007 . . . contains a short discussion about the coverage of Thomson ISI Indexes. It is mentioned that 'journals of



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regional or local importance may not be covered, which may be especially salient for research in engineering/technology, psychology, the social sciences, the health sciences, and the professional fields, as well as for nations with a small or applied science base.'" [Larsen2010]. ***This is not satisfactory for the goal of this project to create, on the Web, a dynamic Knowledge-Repository containing freely-accessible MetaLinks.***

2. CrossRef, the inter-publisher facility to coordinate Backlinks, has a minimum annual charge of $330 [CrossRef2013], which is too expensive for individuals and small organizations.
3. The Backlinks described above have **only minimal information**, and *lack MetaData* that could help Readers (see Link.6, below). {102}

One of the design principles of this project is that, after the open-source programming is completed and made available on the Web, these Tools will not need further commercial or public support, and can operate without top-down supervision (see Discussion). The present "Backlink" arrangement requires commercial support and the continuation of commercial institutions. This is a carry-over from the paper-based publishing model, and is *not appropriate* for the Web-Based Compendium Publishing Model described here. The MetaLink-Protocol allows *any* Journal or Compendium to have MetaLinks. The MetaLink-Protocol ***makes the Web***, **by itself, a *complete Knowledge-Repository.*** {103}

### Link.6 What MetaData Categories are likely to occur in MetaLinks?

The MetaData Categories presently planned to be initially used for AEC-Forums and AEC-Compendia are shown in Fig. 8.

This list is abstracted from pp. 64-73 of the Internet-Draft submitted to the IETF (Internet Engineering Task Force) as an Informational RFC (Request for Comment) [Jewett2015]. {104}

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Fig. 8. A List of MetaData Categories about Text in an Article sent to Linked WebSites.

## ARTICLE

**Static MetaData**

Title,
Subtitle,
Author,
Author-Info,
Consolidator,
Consolidator-Info,
Standard, Full BibRef,
Keywords,
Field of Interest,
Sub-Field of Interest,
HTTP-URL_Display_CitED_Article,
Cookie-Keyword(s),
Language,
Is content open-access?,
Is MetaData open-access?,
Minimum Math BackGround Needed,
Minimum Statistics BackGround Needed,
Questions for CitING-Author, Article,
Contact info: Author email, Consolidator email, WebAdmin email.

**Dynamic MetaData**

Date of Last Update of Article Dynamic MetaData,
Total # of ForwardLinks in Article,
# of new ForwardLinks in Article each Month,
# of new RetroLink in Article each Month,
# Total WebLinks in Article,
# Total non-WebLink References in Article,
# Total of Reader Visits to Article,
# of Reader Visits to Article each Month,
# Total Pages/Words in Article,
Different MetaData-Categories from Other Articles:
- Category name,
- URL of Article with new Category,
- Date this name first Received,
- Keywords of other Article,
- Field of Interest of other Article,
- Disposition of this Category,
- Date of Disposition.

## TEXT

**Static MetaData**

Date First Posting of Text in this Article,
ID of Article#_
ID of Text#_
Text of Text#_,
Preview of Text#_,
Author,
Author-Info,
Consolidator,
Consolidator-Info,
HTTP-URL_Display_Text,
HTTP-URL_MLP_Send_MetaData,
HTTP-URL_MLP_UpDate_MetaData,
Location within Article,
Section within Article (if used),
Questions to CitING-Author, Text
Contact Info: Author email, Consolidator email, WebAdmin email.

**Dynamic MetaData**

Date Last Update to this Dynamic MetaData,
Date Last Change to Text,
Total # of RetroLink from Text,
Total # Clicks of Text from RetroLink,
Total # of ForwardLinks from Text,
Total # Clicks of Text from ForwardLinks,
# new ForwardLinks from Text each Month,
List of Article Comments about Text.



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Fig. 8 Legend: Listed are MetaData-Categories that are processed by the MetaLink-Protocol for a *single Sentence* in an AEC-Compendium, AEC-Forum, or Artical Preprint. The MetaData for the Article, as a whole, are in the left-hand column. The MetaData that applies to the Sentence (Text) are in the right-hand column.
The Questions to the CitING Author provide information not otherwise available to the Reader, such as "Please rate (0-3) the importance of what you are Citing to what you are writing". (All scholars told of this, would strongly welcome this judgement.) {105}

In the MetaData shown in Fig. 8, there are both *Static* and *Dynamic* MetaData about **both** the **Article**, **and** the **Text (Sentence)**. When a LinkPair is setup, *both the Static and Dynamic types of* MetaData, about both the Article and the Text, are sent to the *other* WebSite. {106}
The WebSite containing the MetaData of Fig. 8 updates the Dynamic Metadata as the Article is being read. These changes may be of interest to the Readers. For example, what % of prior Readers have followed a given Link? And, is the % changing over time? Later, if a Reader chooses to see the MetaData for this Sentence in a SortableTable, the Reader's WebSite, using the URL for an update (it is in the Static List), sends a request to ***update just the Dynamic MetaData***, and the SortableTable is updated in the Display, and Database. {107}

The MetaData-Categories shown in Fig. 8 must be expanded by similar data from other WebSites during the LinkPair setup of the MetaLink-Protocol. Thus, this list will enlarge by the number of Categories in Fig. 8 *for every*: 1) *Retro*Link on this WebSite (from different Sentences), and 2) *Forward*Link on other WebSites CitING either this Sentence or other Sentences. Recall that for every MetaLink there are the *same* MetaData Categories in the *other WebSite of the LinkPair.* A fuller list of Categories occupies 8.5 pages, single spaced, in the RFC publication [Jewett2015], but encompasses only one RetroLink and one ForwardLink for one Sentence! (It is certainly nice the computers can take care of all these details!) {108}

The total amount of MetaData is ***not excessive***; realize that the cost of data storage is decreasing over time, and is already sufficiently inexpensive that cost is not a significant issue. Why not save data that may be useful to Readers or later Historians? And why not add Dublin Core MetaData, too [Dublin2015]? {109}



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**Link.7 How ForwardLinks will be used.**

Fig. 9: How a Reader of an online text will find and utilize a ForwardLink.

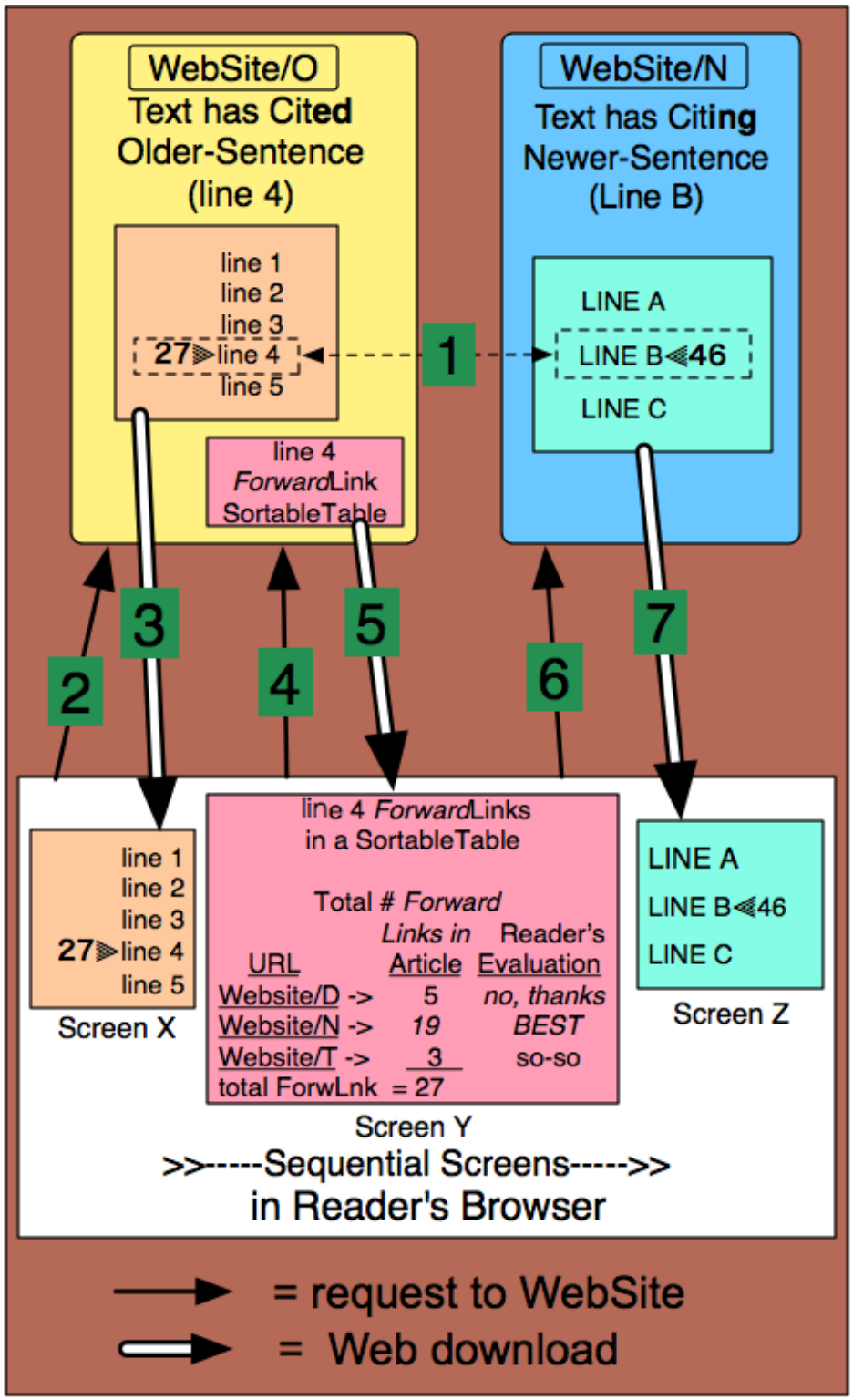




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Fig. 9. Legend: The seven numerals in green boxes show the sequential steps that occur when a Reader utilizes a ***Forward***Link when reading online Text.
IMPORTANT: This Figure shows, in the white box at the bottom, labeled "in Reader's Browser" the three sequential screens that the Reader sees. The screens are labeled X, Y, Z. {110}

The arrows with the green numbers relate to online communications "in the background", as follows:

1. The two WebSites ("O" and "N") have previously communicated and established a ***Retro***Link on WebSite/N (Newer-Sentence) and a ***Forward***Link on WebSite/O (Older-Sentence). The Links are *Sentence-to-Sentence* and the two stored Texts have MetaLink-Icons (that look like multiple 'greater than' or 'lesser than' symbols): 1) on WebSite/N, at the end of Line B, the "⋘46"; 2) on WebSite/O, at the start of line 4, the "27⋙". These Icons provide a cue to the Reader that a MetaLink to the labelled Sentence is present, and that a click will bring about the sequence shown in this Figure. The number in these Icons indicates the total number of ***Forward***Links that a Reader can reach by clicking the Icon. A Reader of WebSite/N, *by following Line B's RetroLink,* will find a total of 46 ForwardLinks on ***all*** of WebSite/O (cue = ⋘46). A Reader of WebSite/O will find 27 *ForwardLinks* from line 4, which is the total number of ForwardLinks for line 4 shown in Screen Y (cue = 27⋙). (See further notes on these cues at Link.8.1.)
2. The Reader (with a blank screen-- not shown) sends a Browser request for the page from WebSite/O. The Reader has not previously seen this page, but has gotten the URL from a friend, or another WebSite.
3. The page downloads onto the Reader's Browser as Screen X. The Reader sees the 27⋙ at the start of line 4, and thinking that this MetaLink could be important to what is being read, clicks the MetaLink-Icon, knowing that this will cause the next action from the Server, namely this will open a SortableTable of MetaData about all of the ***Forward***Links related to this Sentence.
4. The Browser sends the click of the Icon.
5. WebSite/O downloads Screen Y, containing the MetaData of three ***Forward***Links related to line 4, in a SortableTable. ***Figure-Limitation Alert:*** The data shown in this Figure is *diagrammatic only, and* does ***not*** *show* the full complexity seen in a real SortableTable. The Reader can choose (now or previously with cookies saved on the computer) from *all of the Categories in Fig. 7 related to the*



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*ForwardLinks, about the Article and/or Sentence*. For any Categories so chosen, the data from the three WebSites (D, N, T) will be in different rows of the Table, for direct comparison. None of this detail is shown in this Figure. **Back to "the action"**: we assume that the Reader has evaluated the MetaData (judgements shown in the column labeled "Reader's Evaluation") and decided that WebSite/N is best to look at; the Reader then clicks the WebSite/N URL Link in order to see more.

6. The Browser, using the URL from the SortableTable, sends a display request to WebSite/Node.
7. WebSite/N downloads Screen Z, showing the page containing Line B, so the Reader can investigate further. The Line B has a MetaLink-Icon "⋘27" so that a Reader of the Article on that WebSite will be aware of the MetaLink-Pair. The number is showing the number of ***Forward***Links available on WebSite/O. This feature is discussed further in Link.8. {111}

**Link.8 Unique features of ForwardLinks (that are *not* in "Backlinks")**

In addition to the *generic* advantages of ***Forward***Links mentioned previously, here are some of the *unique features* of ***Forward***Links (not available in present "Backlinks"):

1. The MetaLink-Icons are placed within the CitED and CitING texts to alert Readers to the increased information that is immediately available if they click the Icon. The CitED text will have an Icon at the start of the Sentence (*e.g.*: #⋙This Sentence has been CitED.). The CitING text will have an Icon at the end of the Sentence (e.g.: This is a CitING Sentence with a standard Reference [RefExampleOnly2015].⋘#) The Icons also have an attached number (#) that indicates the number of ***Forward***Links that will be available to the Reader by following the Link, either from the CitED Sentence (#⋙) or from the CitED Article (⋘#). (These MetaLink Icons are also shown in Fig. 9, above.)

One may wonder "why this number"? With the large amount of information available (see Fig. 8), it is clear that the Icon, with but a single number, can communicate only a minuscule summary. What should the number (or symbol) next to the MetaLink-Icon summarize? As described in detail in this Section (Link.8), ***Forward***Links are **very** important to a Scholar because a ***Forward***Link points to an Article that is *newer and related to the topic* of the Article on the OlderSentence-WebSite. So, it is likely that the Reader will want to consider



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how many ***Forward***Links can be found on different paths. For this reason the limited space in the MetaLink-Icon is devoted to the *total number of* ***Forward***Links that can be accessed by a given click. There is an asymmetry, however. The Reader of the CitING Sentence will want to know the number of ForwardLinks *in the whole Article,* since **other** Sentences of the article may be CitED more times than the CitED Sentence. On the other hand, the Reader of the CitED Sentence will want to know the *total number of ForwardLinks that will be available* in articles that *have CitED the Sentence.* Note that *this number* is only used by the Reader to decide whether to click the Icon to see the SortableTable, or not. After a click, the SortableTable provides considerable, additional MetaData for the Reader to decide whether to jump to another Article.

2. ***Forward***Links are Citations from *Sentence-to-Sentence*, so the Reader does not have to search the entire article for the relevant part (as occurs with Backlinks that point to an entire article).
3. ***Forward***Link MetaData contains Questions posed by the Consolidator of the Cit*ed* Compendium, with Answers from the Cit*ing* Author (the methodology is described in detail in Jewett2015). These Questions will include the Author's estimation of the importance of what is being Cit*ed* to what is being written. This estimate is likely to of considerable help to the Reader when determining whether or not to follow the ***Forward***Link to the newer material. The availability of the Author's Answers in the Database means that this information can *also be made available* to any Reader following a ***Retro***Link, and it is.
4. ***Forward***Links carry substantial MetaData about the Citing Article and about the Citing Sentence.
5. The MetaData is presented in SortableTables. The Reader can choose which columns to display, and which column to sort on. Cookies are placed on the Browser so that the SortableTable display chosen by the Reader can be the same for another search. Several sets of Cookies can be saved, for different topics, fields, or interests of the Reader. **This is important because there will be an increased number of scholarly-Links if there is an increased number of scholarly AEC-Compendia. Similarly, as MetaLinks are used more by Journals for their articles, there will be increased MetaData available.** Thus, Readers ***should be offered help*** in analyzing the increased Link-information.
6. The MetaData Categories are those of interest to Readers in the field of the Article or Compendium because the Categories have been chosen by either the Author of the Article or the Consolidator of the AEC-Compendium-Forum. The



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Categories will gradually adapt to the needs of individual fields of scholarship, or to changing topics of interest within a field, as shown in Link.9. {112}

**Link.9 Questions and MetaData Categories that adapt *via* a Loop**

There is a natural Feedback Loop that gradually adapts Questions posed to the CitING Author and MetaData Categories, to the needs of Readers. This Loop means that the Forum-Consolidator can modify the Questions and MetaData-Categories for the specific needs of specific fields, and can also keep them up-to-date as the field changes over time:

1. First of all, the Forum-Consolidator is a Reader in the field of the Forum, and so will initially set-up most of the Questions and Categories to fit the narrow-topic chosen for the AEC-Forum.
2. Further, Readers can send comments about an AEC-Forum to its Consolidator. The Forum-Consolidator has Forum-Software Tools to add to, or modify, MetaData-Categories in the AEC-Forum.
3. The Forum-Consolidator also is aware of any MetaData-Categories used by other WebSites that are Linked to the Consolidator's WebSite (as part of the MetaLink-Protocol). {113}

**Link.10 How does the MetaLink-Protocol affect Digital Archives?**

The MetaLink-Protocol makes possible a ***new format of online digital archive***! A Passive Archive can become an Active Archive by utilizing the MetaLink-Protocol Software. (See Definitions, next) {114}

**Definitions, Archives**:

**Passive Archive** = an online database/archive in which ***neither*** *Content* ***nor*** *MetaData* changes over time. The Content includes standard Citations. This Archive does *not* conform to the MetaLink-Protocol.

**Active Archive** = an online database/archive in which the archived-C*ontent* ***never*** *changes*, whereas the *MetaData* ***does*** *change* because the WebSite has functioning Software conforming to the MetaLink-Protocol. In consequence, an Active Archive WebSite, over time, develops more and more ***Forward***Links (from newer citations), while the Archive's ***Retro***Links remain the same. (New ***Retro***Links would occur *only* if the *Content were changing.*) {115}



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The **distinction** between ***Passive and Active*** **Archives** is *not trivial, at all!*

A Passive Archive ***loses value*** over time because both the content and (limited) MetaData becomes older and less relevant. The information in the *online* library decays just as it does in a *paper* library! {116}

An Active Archive ***gains value*** over time because, although the content and citations do not change, **the** ***Forward***Links **are** ***up-to-date*****.** This value increases as the article content becomes older (and less useful), because ***the number of ForwardLinks*** (which add value) ***will increase with time***. A Reader interested in discovering new developments in a given line of research, **will seek-out WebSites that offer the** ***most*** ***Forward*****Links.** (So, too, will historians of a field.) {117}

**Indeed, in the future,** Articles **may be ranked on the number of** *Forward*Links **they contain, since this is the same as the number of Citations the Article has** ***received*****.** Recall that a ***Forward***Link is only created on a CitED WebSite in response to a ***Retro***Link (Citation) on a CitING WebSite, so that the number of ForwardLinks that an Article has is the same as the number of RetroLinks that point to some part of the Article. The number of ***Forward***Links within an Article can easily be found by a Reader by sorting on the column in the Sortable Table headed "Number of ***Forward***Links Available on this Article", which is one item of Dynamic MetaData for "Article" in Fig. 8. {118}

Furthermore, in the future **Archives** ***may also be ranked on the number of ForwardLinks they contain.*** *Such a ranking would be a disaster for* Passive Archives, since they do not contain ForwardLinks. There is an immense amount of content in present Passive Archives, which would be much more valuable if Passive Archives are transformed into Active Archives! The transformation to an Active Archive involves *only adding* the MetaLink-Software from this Project to the Software of the Passive Archive. When the MetaLink-Software is running, new ***Forward***Links will be added to the Archives Database, as newer articles or AEC-Compendia cite a Sentence within the Active Archive. {119}

The display of Text of an Active Archive displays the MetaLink-Icon (#⋙) at the start of each Sentence that has one or more ***Forward***Links. If the written material in a Passive Archive is in alphanumeric characters, the ForwardLink-Icon (**#⋙**) can be easily placed at the start of the Sentence by the Software. If the Passive Archive has been saved in



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a non-character format, then a screen overlay can be used. {120}

AEC-Compendia, after they are no longer actively changing, should be "retired" in Active Archives of a University, Endowment, PubMedCentral, or equivalent. AEC-Compendia are contributions to Knowledge-Creation, and should be kept just as books and articles are. {121}

Such a "store" of "retired AEC-Compendia" could play an important part in Knowledge-Creation. New findings in other fields may cause a re-examination of the field of a "retired" Compendium that could be brought out of "retirement" by the same procedures as mentioned in Section Node.6.5 (above), to be part of a new AEC-Compendium-Forum dealing with this "new review" of an "old area". (Historians of science should *love this*!). {122}

Archived AEC-Compendia should also be indexed in the same way as articles (*e.g.*, PubMed) since they provide Knowledge about groups of articles that is not available from the articles themselves (Fig. 1). This would increase the value of the indexes, as a good source of ***Forward***Links (to Articles and to AEC-Compendia). {123}

### Link.11 The Advantage for Active Archives of the MetaLink-Protocol

Since the importance of a whole WebSite is likely to depend on the number of ***Forward***Links it has, if two WebSites contain the ***same material***, the WebSite that ***first*** *puts the material* ***online*** will have an advantage. This occurs because in order to create a ***Forward***Link on the Cited WebSite, the Author must have online access in order to specify the Cited Sentence, and to answer the questions posed, and then to receive the specific unique identification that is needed for inter-server processing under the MetaLink-Protocol [Jewett2015]. {124}

The fact that the MetaLink-Protocol provides an advantage to the "first online" has particular relevance to PubMedCentral, which currently publishes NIH-supported research papers within one year of publication. The date that publishers put a paper-published work online must always *precede* the PubMedCentral publication date, *in order to avoid their giving away the advantage* described above. In fact, the sooner the publication is online, the greater the advantage. The consequence could be that the duration of the "Limited-Access Blackout" may be shortened by Publishers, in their own self-interest. {125}



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The MetaLink-Protocol provides a bonus to Open-Access publishing because Open-Access publishing increases the number of potential readers. Thus, an Open-Access Publishing WebSite is more attractive to an Author because of the potential readership, when the Author is deciding which online sources to cite. The CitED WebSite gains the ForwardLink-Advantage of increasing value, described in the first paragraph of this section. {126}

**Link.12 Comparison of: Current WebLinks and New MetaLinks**

Fig. 10: Comparison of Current WebLinks, and New MetaLinks, on ***three pages.*** {127}

| **Comparisons of ⇒ ⇒ with respect to ⇓ ⇓** | **Current WebLinks** | **MetaLinks by the MetaLink-Protocol** |
|---|---|---|
| Link Names | URL & Backlink | *Retro*Link & *Forward*Link |
| Link Name intuitive for Reader | Not at all | Yes |
| MetaData about Article/Author | n/a | Yes |
| MetaData Categories determined by | n/a | Authors and Readers |
| Displayed MetaData Categories Adapt to Different Fields; new needs | n/a | Adaptations evolve with use/time |
| Participation of Author-Expert | Input *only* via keywords for Author's Article | Input of MetaData of direct relevance to Readers, including Author's estimate of the importance of the CitED text to the topic of the Author's Article. (Keywords also available) |
| Reader-controlled sorting of Link MetaData | n/a | On SortableTable columns of interest, Reader selected: e.g., date, keywords, author-provided importance of link, etc. |



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| Comparisons of ⇒ ⇒ with respect to ⇓ ⇓ | Current WebLinks | MetaLinks by the MetaLink-Protocol |
|---|---|---|
| Ease of Link evaluation, for Reader | **Awkward**, with multiple steps and no way for the Reader to evaluate the usefulness of a possible jump to new content | **Easy, with** immediate display of citING or citED text; Reader-chosen sorting/display of MetaData of most interest to the Reader |
| Specificity of Link | ***Too Coarse*** (Regular citations pointing to complete Articles); *or* ***Too Fine*** (Word or phrase found by WebSearch Engine) | ***Medium*** (Sentence-to-Sentence Citations, at the level of ideas, in both *Forward* and *Retro* directions.) |
| In citED WebSite: Reason that Author is citING the citED Sentence | n/a | Provided by easily-displayed citING sentence |
| Ease, for Author, of creating a Citation, | Multiple copy/paste from multiple sources | Single copy/paste |
| Creation of *either* "*Back*link" (Current) or "*Forward*Link" (MetaLink) | **ONLY IF** "Recognized" by Web of Science, or Payment of fee to special publisher organization that covers less than 50% of scientific publications | Direct, on the Article's WebSite, using free software |
| Archive's changing value | Value **decreases** over time, as **content** becomes "out-of-date" | Value **increases** over time, by keeping **Links** "up-to-date" with later developments |
| Automation | Proprietary Software | Open-source software |
| Encourages Open-Access publishing by individuals or small groups | No | Yes, *Forward*Links will indicate which Links are to Open-Access WebSites |



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| Comparisons of ⇒ ⇒ with respect to ⇓ ⇓ | Current WebLinks | MetaLinks by the MetaLink-Protocol |
|---|---|---|
| Financial Cost to Readers | High -- to access Publisher's Websites and Web of Science; Reader may need university affiliation to cover fees | Links free, Content Free via Open-Access Publishers |
| Support needed to start | None-- Commercially exist | Coding of Open-Source Software |
| Continuing support needed | Commercial or Public Funding of Databases & Servers | None |

(no legend for Fig. 10)

**Link.13 Knowledge-Slices on the Knowledge-Repository**

The Web-based Knowledge-Repository that has been described will provide an interesting way to automatically classify "slices" of Knowledge. The totality of Knowledge is multi-dimensional, where "dimension" denotes variables that distinguish some parts of Knowledge from other parts. Usually the parts of Knowledge are distinguished based on words and phrases, which, over time, gain adjectives to provide new sub-divisions. {128}

What the presence of MetaLinks *within* every scholarly publication on the Web provides is the opportunity to distinguish lower-dimensional "slices" within the higher-dimensional "totality". The slices can be operationally defined based on the Citations upon which the MetaLinks were created in the MetaLink-Protocol. These Citations indicate connections within the Knowledge-Repository that have been made by experts knowledgable about the details of a specific Slice or of parts of a Slice. Software could be devised to Web-crawl, starting from a given Article (in an Active Archive) and following the primary RetroLinks and ForwardLinks available in the Articles. These Links would define the "slice" of that given Article. {129}

The primary Links will lead to secondary Links in connected Articles, and then on to tertiary Links, *etc*. Truncating the "Link-depth" may provide networks of Articles on the Web that provide different kinds of information, such as "Master" Articles that join



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together many otherwise-separate Slices, or such as isolated "Slices" that are not linked with Citations, despite sharing keywords. Such compilations may be of interest to scholars compiling the history of a given idea, or wishing to show the divergent processes that can occur. Funding agencies that wish to review the effects of policies in prior years might find some information valuable. And then there are promotion review committees. . . {130}

## Discussion

Much of the Discussion has been included within the Methods presentation, previously (*q.v.*).

A List of the Principles that have governed the design of both Nodes & Links, includes:

1. All software must be Intuitive-to-use for present Web-Users (*i.e.*, no manuals needed).
2. The Software must utilize existing Browsers and Word-Processors.
3. Centralized administration or support must not be required (after open-source software development and distribution).
4. There must be Open-Access at all levels.
5. All code must be Open-Source for all Nodes & Links.
6. Both Node and Link creation must be able to adapt, over time, to changes in scholarly needs. {131}

While the long-term plan is that neither Central Support nor Central Control will be needed for either AEC-Forums or MetaLinks, initial support is absolutely needed to provide the necessary Open-Source Software. After release of the Software, there may be need for additional financial support for the following:

1. For a WebSite to host a SlashDot program to evaluate posted Compendia, and to "GreyList" poor Sites.
2. For a WebSite to provide CHA seed numbers until minimum LinkPair requirements for adequate security are met.
3. For a WebSite where volunteers can provide additions/changes to Software as continuing improvements. {132}



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## Conclusion

There is an ancient curse: "May your wishes be granted". What scientist would not wish to reach into the present fount of information/knowledge and slowly sip the cool, clear water presently shooting, full force out of a **firehose of 3,700 articles *a day*** [Bjork2009]? That was in 2006! How many **firehoses are there today?** {133}

Extending the metaphor, the firehoses are spraying the top of a giant iceberg where only the top 10% is above the sea level. Active scientists search around the top using keyword searches, while the vast majority of the stored information/knowledge is locked away, inaccessible under cold water. {134}

Is our Knowledge increasing? Yes, but not in proportion to the "flow", but only in proportion to a numerical increase in Specialists utilizing just a small part of the information that has been produced. ***Knowledge-creation is not keeping up with the output of the firehoses!*** {135}

Contemplation of this situation should lead us to admit that *the present paper-publishing model is* ***failing us***. No solutions, public or private, are on the horizon. {136}

This Article has presented two *new* methods to *markedly change* the situation:

1. Building Open-Source Software so that Knowledge-Creation can be easier and faster *via* AEC-Forums. The AEC-Forums are the basis for creating *a new form of peer-reviewed "Review-article" in a MultiLevel Format* (AEC-Compendia). A multitude of motivated post-docs [Nature2016], pre-docs, and medical/surgical residents will start and manage the online AEC-Forums. These "Knowledge-Consolidators", all motivated by their own self-interest, will be aided by their mentors and online experts. The Costs will be minimal. The AEC-Forum Software can also be used to speed publication on the Web because it will support Publication Preprints with online peer-review.
2. Building Open-Source Software for better WebLinks based on a new MetaLink-Protocol. The Software will provide all WebSites with the opportunity to display both Forward- and Retro-Links, the Links being based on human judgments of the intellectual connections between otherwise disparate Knowledge-Sites on the Web, even if the Sites do not share *any* keywords. {137}

The new methods will be:

1. adaptable to the needs of users;
2. widely-available;
3. used easily by all participants;



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4. without need for central control;
5. useful even on icebergs. {138}

## Supplemental Material

In the Supplemental Material is a detailed, 73 page description of how the *MetaLink-Protocol* will work. The description includes Figures and Descriptions of general issues, and also describes the Software Modules needed.

This material was originally submitted to the Internet Engineering Task Force as an Informational Submission. In accordance with their rules, it was automatically removed from their WebSite after a fixed interval.

NB: Small changes in terminology and Icons are listed on the first page.

## Software Availability

At present no Software is ready to be released. We have programmed various "proofs of principle" to show that the goals can be achieved with Software additions to one Content Management System, the TikiWiki Content Management System Groupware. We have determined that a consistent, easy to use format can be accessed, modified, and controlled by available word processors. We now know that the TikiWiki "Forum" mode can be modified to allow all of the other procedures described here, including restrictions. TikiWiki, Drupal, and Joomla! (all PHP based) can incorporate Software for the MetaLink-Protocol written in PHP. Other PHP-based Content Management Systems should also be able to incorporate the Open-Source Software. These statements apply to both the Software and the MetaLink Software. {139}

Online Archives with LAMP Servers (Linux, Apache, MySQL, PHP) will be able to use the PHP Software for the MetaLink-Protocol, and thus become Active Archives. {140}

## Competing Interests

The Author is the Research Director, and majority stock holder of a small business, Abratech Corporation. He is also the Principal Investigator on the NIH grant that has supported this effort so far (see next section). By the conditions of the grant, it is required that Abratech commercialize some aspect of the work. The Author is



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convinced that to gain sufficient support for these ideas to "take off", the Software for both AEC-Forums and MetaLinks must be open-source, and freely available. Thus, there is no commercialization possible from Software sales. {141}

For this reason, when the Software is ready for release, Abratech Corp. will offer "ready-to-go" "Hosting Packages" that can be used to bring a AEC-Forum up and running online within (a goal of) ten minutes. While many Consolidators may use Institutional servers for hosting a AEC-Forum, other Consolidators may not have such facilities, or may not want to use them. This commercialization will remove the need for (time-consuming) downloading and installing of the (Open-Source) Software-Components needed for a useful AEC-Forum. In this way, the commercialization interest avoids conflict with the "Gift Culture" that is highly valued by those likely to be Consolidators (and by this Article's Author when he is doing research). The "Hosting Package" plan may actually be essential for AEC-Forums and MetaLinks to succeed (by becoming "viral"), and, if so, will play a useful role in the overall goals of improving Knowledge-Creation and Post-Graduate Education, while providing a commercialization success for the SBIR program. {142}

There are no other Competing Interests.

## Grant Information

The project described was supported in part by Grant Number R43LM010734 from the National Library of Medicine. The content herein is solely the responsibility of the author and does not necessarily represent the official views of the National Library of Medicine or the National Institutes of Health. {143}

## Acknowledgments

Early concept-collaboration with:

Robert Plantz, PhD, (Concepts)

Dana Rottach, PhD, (Concepts & Programming Approaches)

Later collaboration with:

Robert Plummer (Programming)

Mary Luketich (WebSite construction)

Essential editing and critical review of ideas by

Virginia Meyer, JD {144}



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