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Adapted Primary Literature (APL):

An Effective Authentic Text Option for the Science Classroom

by

Lauren Thresh

A thesis submitted to the Department of Education and Human Development of The College at Brockport, State University of New York, in partial fulfillment of the requirements for the degree of Master of Education

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By Lauren Christine Thresh

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Introduction

The intention of this literature review is to advocate for the incorporation of Adapted Primary Literature (APL) into secondary science classroom instruction in order to aid such science curriculum in achieving balanced authenticity. APL is a valuable instructional text option due to its novel design, an optimal compromise between authenticity and accessibility. APL is a superior reflection of authentic science as it is for professionals of science and in representation of the nature of science (NOS) than Secondary Literature (SL) and textbooks, the dominating scientific text genres of most secondary science classroom instruction. Yet, APL is more accessible in text sophistication and structure than arguably the most authentic genre, Primary Scientific Literature (PSL).

In other words, due to such negotiated design, APL could prove invaluable at addressing a multitude of science education objectives associated with authenticity, such as those pertaining to the following common categorical headings: literacy, argumentation, inquiry, concept competence, and the nature of science, to name a few. In addition, APL may address the contemporary science education goals of increased student interest, motivation, and pursuit of scientific endeavors. After all, the current and likely future direction of the global economy, professional atmosphere, consumer decision-making, technological advancements, and environmental threats has required that science education be concerned with far more than just student memorization of content within an isolated, singular disciplinary year.

Suggested remedies for potential incorporation challenges, areas in need of further research, and common contrary research positions will be included to provide a comprehensive and supportive examination of APL implementation. No instructive technique is without tradeoffs. Like any other educative method, the success of APL implementation is greatly

influenced by the quality of surrounding instruction. Possessing scientific authenticity “in some defined way is never sufficient justification by itself for engaging in an educational practice. Authenticity is no guarantee of effectiveness” (Norris et al., 2009, p. 407).

Authenticity

Authentic Label

A culmination of the Primary Scientific Literature (PSL) results in a plethora of descriptors and associations as to the meaning, achievement, and rewards of authenticity to science education: development of models, explanation of phenomena, “language and discourse practices,” and “recognition of the strengths and weaknesses of scientific claims”, to name a few (Chiu, Dejaeger, & Chao, 2015, p. 59; Ford, 2009, p. 387). Researchers of ‘authentic’ science education argue that such termed learning experiences possess a unique and effective capacity to gain learners access to scientists meaning and purpose, promoting student adoption of scientific practices by way of understanding the “attitudes, tools, techniques, and social interactions” of science (Falk & Yarden, 2009, p. 353). Although the value of ‘authentic’ learning experiences toward achieving numerous contemporary science education objectives, including those of the NGSS, seems to be well agreed upon by leaders of such study, the necessary constitution of an exercise to earn the consideration of ‘authentic’ remains heavily debated.

Some measure the degree of a learning endeavor’s authenticity with regard to its accurate reflection of practices as they are conducted by professionals of science related fields (Osborne, 2009, p. 400). Others protest such a correlation, providing the example that a sports commentator need not have excelled as an athlete to become revered in their profession (Osborne, 2009, p. 400). Objectors continue that this overused definition of authenticity promotes “a singular,

imperialist conception of the nature of science”, resulting in “grave misconceptions” (Ford, 2009, p. 386).

Rather, some field experts regard the extent of a learning experiences authenticity in terms of the knowledge enhancement and comprehension enlargement that occurs as a result of the activity, in addition to the accompanying feelings “of success, revelation and meaning” that follow (Osborne, 2009, p. 400). In this way, authenticity is not a label of judged genuineness by one or a committee of professionals, but is “earned” as a result of an individual’s commitment “to seek understanding and purpose” from an experience (Osborne, 2009, p. 400). In other words, the all too common definition of authenticity as solely dependent upon “activity-based school science curricula that emphasizes strictly empirical approaches” must be broadened beyond this outdated view to encompass the knowing that “learners can define their own authentic interactions with nature” (Ford, 2009, p. 386).

For this literature review, the term ‘authentic(ity)’ - any comparison to it or measure of it - encompasses the most frequent arguments by research best practices: (1) science as it is done by professionals of scientific fields, (2) accurate representation of the nature of science, and (3) reflection of future citizens’ likely science encounters.

‘Hands-on’ vs. ‘Minds-On’

It has been suggested in the research that there are two forms of authentic investigation or inquiry: “first-hand” and “second-hand” (Falk & Yarden, 2009, p. 353). Science investigations that fall under the ‘first-hand’ category - perhaps more commonly known as ‘hands-on’ - are “the manipulative” and “experimental” that allow for student problem solving (Norris, Stelnicki, & Vries, 2012, p. 634; Falk & Yarden, 2009, p. 353). The ‘second-hand’ - or ‘minds-on’ - consist

of results obtained by scientists, typically presented to students through software or text (Norris et al., 2012, p. 634; Falk & Yarden, 2009, p. 353). ‘Hands-on’ has received much of the authentic attention by past science curricula, neglecting the valuable and, perhaps, irreplaceable benefits of ‘minds-on’ to authentic objectives (Norris et al., 2012, p. 634; Falk & Yarden, 2009, p. 353).

Providing further justification to the authenticity of ‘minds-on’, research has found that a great deal of scientists’ understanding is acquired from others’ “thoughts and experiences”, or second-hand learning (Falk & Yarden, 2009, p. 353). Advocates of ‘minds-on’ explain that a significant portion of science is not solely “nitty-gritty” experimentation, observation, manipulation, or data gathering, but “conceptual and theoretical”, “concerned with ideas”, rational, thoughts, theories, and communication activities (Phillips & Norris, 2009, p. 314; Osborne, 2009, p. 397-398). Even when ‘hands-on’ is conducted, ‘minds-on’ is pervasively surrounding, infiltrating, mediating, and consuming the activity. Therefore, Falk and Yarden recommend treating ‘hands-on’ in terms of “providing evidence for knowledge claims”, rather than only “procedural practice” (2009, p. 353).

Researchers vary in their opinion of which is more significant to scientific understanding and, therefore, science education: ‘minds-on’ or ‘hands-on’. Osborne supports ‘minds-on’ superiority, stating that ‘hands-on’ is a subsidiary activity, thoughts ““are the crown of science, of in them our understanding of the world is expressed”” (2009, p. 397-398). Others more evenly feel that dismissing ‘minds-on’ as a “part of science” and only regarding ‘hands-on’ as real science is “wrongheaded” (Phillips & Norris, 2009, p. 314). Debate persists as to which component - ‘hands-on’ or ‘minds-on’ - reigns supreme. Ranking aside, there is agreement on the necessity of both to science, just as there is relative universality regarding the incapability “to

conceive of science without reading or writing” (Osborne, 2009, p. 397). Phillips and Norris explain mental ‘minds-on’ activities are “mediated by spoken and written language” - “reading, writing, and speaking” – or scientific literacy (2009, p. 314).

Scientific Literacy

Significance of Literacy to Science

It is argued that an understanding of sciences written languages is “an authentic practice, whether within a scientific community or within a school science community” (Ford, 2009, p. 386). According to Phillips and Norris, reading is regarded by scientists “as essential to their work and as” a “primary source of creative stimulation” (2009, 314). By conducting a survey of scientists, Tenopir and Kind provide quantitative data to support this significance of reading to science. They determined that roughly 23% of a scientists total work time (or 553 hours per year) is spent reading, with “award-winning and high-achieving scientists” from the survey selection exceeding this allocation (2004).

Broadening the examination beyond the reading component of scientific literacy, Phillips and Norris found, on average, 58% of surveyed scientists total work time is spent in a form of communication, whether speaking, writing, or reading (2009, 314). This figure supports one of their argument statements from an earlier publication; “reading and writing are inextricably linked to the very nature and fabric of science, and, by extension, to learning science” (Norris & Phillips, 2003, p. 226). It is no surprise, then, that scientific literacy is part of contemporary education’s effort to provide future citizens with decision-making capability (Falk & Yarden, 2009, p. 351).

Meaning of Scientific Literacy

Research has defined two components of scientific literacy: the “fundamental sense” and the “derived sense” (Falk & Yarden, 2009, p. 351). According to Norris and Phillips, the fundamental pertains to abilities associated with the reading, interpreting, and writing of scientific text, while the derived refers to knowing “scientific ideas” and applying them in a “scientific manner” (2003). To form the whole that is scientific literacy, the two “support and complement each other” in either direction: certainly one must be able to accurately read a text before interpretation can begin, however connections made within the text and to outside knowledge are necessary for interpretation (Norris & Phillips, 2003, p. 236). Inquiry thinking is argued to reside within the derived component, as it is under this side of the coin that scientific thinking is considered to fall (Falk & Yarden, 2009, p. 351). As stated by Falk and Yarden, “at the core of scientific literacy” resides scientific inquiry and the nature of science (NOS) (2009, p. 351).

Reading as/by Inquiry

Researchers argue that the “mental activities” involved in reading science texts are quite similar to those “central to science”, including the so-called doing of science, or inquiry (Phillips & Norris, 2009, p. 318). Phillips and Norris argue that “reading is principled interpretation of text.” Readers of science recognize links between “relevant background knowledge” and text information. This detection is then followed with an integration of such connections that allows for inference, exploration, and interpretation. Phillips and Norris enlighten that in this way, reading, in itself, can be considered an act of inquiry (2009, p. 318).

Inquiry learning, similarly to authentic science investigations and scientific literacy, has been considered in terms of two dimensions: “learning science as inquiry and by inquiry” (Falk & Yarden, 2009, p. 351). ‘As inquiry’ refers to understanding the progression of science,

including historical perspective of other's inquiry process (Falk & Yarden, 2009, p. 351). 'By inquiry' involves abilities associated with doing scientific inquiry: questioning, hypothesis generation, experimental design, evidence analysis, argumentation, recognition of "alternative explanations," and communication (Falk & Yarden, 2009, p. 351).

Nature of Science (NOS)

Understanding the nature of science (NOS) shares a relation with learning science *as* inquiry, in that NOS represents "science as a human endeavor", including "the values, influences and limitations intrinsic to scientific knowledge" (Falk & Yarden, 2009, p. 351). Contemporary science education considers student understanding of the following three aspects of NOS important to current objectives: (1) "the nature, production, and validation of scientific knowledge," (2) "the internal and external sociology of science, and" (3) "the processes of science" (Falk & Yarden, 2009, p. 351).

Argumentation

Arguably eclipsed by 'hands-on' dominating trends in science curricula, "critical inquiry into written scientific arguments is nonetheless a central focus of scientific practice" (Ford, 2009, p. 386). In addition to the obvious value as a source of factual information, Ford argues that scientists more predominantly utilize professional texts for two general purposes: (1) as a means to formulate "carefully written arguments" that demonstrate their passion for science and that attempt to convince "others about the legitimacy of their ideas", followed by (2) other scientists evaluation of the argument (2009, p. 387). Extrapolating on the latter, an indication of scientific expertise and a central constituent to understanding the nature of science is "the ability to evaluate written arguments" (Ford, 2009, p. 386). Therefore, it stands to reason that in order for

students “to understand the ideas of science,” they “must necessarily understand the conventions of language used to present and support these ideas to an informed audience” (Ford, 2009, p. 386).

Science Education Must Include Literacy

Literacy is an “activity that makes science what it is, and to neglect it is to distort the nature of science to a degree” (Norris et al., 2012, p. 634). Baram-Tsabari and Yarden explain that “‘true’ scientific literacy” encompasses “elements of scientific investigation”, such as ‘scientific habits of mind’ (logical reasoning, evidential reliance, experimental role, critical thinking). In addition, an individual truly literate in science possess’ an ability to utilize their scientific “thinking for individual and social purposes”. In this way, the authors urge, for current science students to gain a ‘true’ scientific literacy that allows them to participate in future decision-making as it pertains to science in everyday life, they must be taught “not only what science can do, but...how science is done” (2005, p. 404).

Text Genres

In order for science education to possess authenticity, by any definition, and reap all the benefits associated, authentic scientific texts must be incorporated into instruction. Text genres are “defined by function, sociocultural practices, and communicative purpose” (Baram-Tsabari & Yarden, 2005, p. 404). According to Goldman and Bisanz, the “communication of scientific information” has three chief functions “in our society”: (1) “communication among scientists;” (2) “popularizing information generated by the scientific community;” (3) “providing formal education” (2002, p. 21). For the purposes of this scientific text analysis, consider these three roles as they reside on a spectrum. On one end of the scale lies expository texts, with the intent

“to expose information or ideas” (Baram-Tsabari & Yarden, 2005, p. 404). On the opposite end of the continuum exists narrative texts, a category written more for entertainment and/or educational purposes (Baram-Tsabari & Yarden, 2005, p. 404).

Found toward the expository text pole is Primary Scientific Literature (PSL), such as scientific research articles, which qualify under the first communication role (Baram-Tsabari & Yarden, 2005, p. 404). While Secondary Literature (SL), including Journalistic Reported Versions (JRV), such as a “popular-science article”, the second communication role, reside toward the narrative text tail (Baram-Tsabari & Yarden, 2005, p. 404). Traditional adolescent science textbooks, the third communication role, would also fall near the narrative text tail (Baram-Tsabari & Yarden, 2005, p. 404).

As for which is more narrative in nature, SL or textbooks, there is no consensus in the research. It would likely depend upon the particular texts being compared. In addition, whether or not SL is used for educational purposes, and therefore qualifies for consideration under communication role three, would depend upon the instructor or school/district curriculum. Yarden proposes yet another underlying spectrum to consider here, a gradual transition from “real science” to “school science”, with real science by PSL and communication role one, and school science by textbooks and communication role three (see Appendix A for a visual representation of this scientific text genre analysis) (2009, p. 309).

Primary Scientific Literature (PSL)

PSL Defined

PSL (Primary Scientific Literature) - “found in journals, technical reports, conference proceedings, patents,” and “theses” – are the “original writings on a science subject” (Norris,

Macnab, Wonham, & Vries, 2009, p. 322). Simply put, PSL “is written by scientists for scientists” (Norris et al., 2009, p. 322). Reminiscent of previous discussion, this text genre is primarily argumentative: consists of evidence supported conclusions (primarily located within the Methods and Results sections), possess’ a canonical structure (Abstract, Introduction, Methods, Results, Discussion), and presents scientific uncertainty (Yarden, 2009, p. 307-309). Information about the practice and representation of the scientific process in laboratories and “workplaces of science,” in addition to chronicles “of how and why knowledge evolves”, is contained within this text genre (Norris et al., 2009, p. 322).

Value of PSL

Reading such texts is arguably as close to performing authentic practices of science as one can achieve, second to conducting or participating in the study itself. Therefore, as Yarden, Brill, and Falk conclude, PSL has the invaluable potential to substantially shrink the all too prevalent separation “between public knowledge and the frontiers of scientific inquiry” (2001). The authors further explain that PSL can aid in student development of the following scientific literacy elements: research plan rational, research methodology and appropriateness to the research question, scientific communication’s structure and language, critical assessment of scientific research conclusions and goals, and the scientific research process’ continuity (Yarden et al., 2001). Baram-Tsabari and Yarden supply additional benefits of PSL reading to science education, student skill development with “the nature of scientific reasoning” and “scientific investigation”. The same researchers also provide the enlightening perspective that “students may find reading research articles a novelty and a challenge”, aiding in student motivation and higher-level scientific comprehension (2005, p. 404).

Challenges of PSL

Yet, the “jargon and technical language specific to the area of research” can render such sources problematic for “non-scientists,” such as adolescent students and educators, to understand (Norris et al., 2009, p. 322). Unlike popular science media, research articles are far more tolerant of “information gaps” and lack “reader-friendly” features, such as “metaphors, analogies and examples” (Baram-Tsabari & Yarden, 2005, p. 404). In addition, science writing utilizes “passive voice,” substitutes “abstract nouns” for “verbs,” and replaces “verbs of material action” with “verbs of abstract relation” (Baram-Tsabari & Yarden, 2005, p. 405). Such qualities have a tendency to exclude and alienate learners (Baram-Tsabari & Yarden, 2005, p. 405). “According to a statistical formula for the objective measurement of readability, scientific magazines”, which are categorized under PSL, earned a low “reading ease” score, resulting in a rank of “very difficult” (Baram-Tsabari & Yarden, 2005, p. 405). The trade-off to authenticity, in this case, is accessibility.

Secondary Literature (SL)

SL – Definition, Pros, and Cons

Perhaps the most reader friendly and broad audience accessible forms of scientific text are SL (Secondary Literature) or JRV (Journalistic Reported Versions), such as “newspapers and magazine articles” (Norris et al., 2009, p. 322). The press of such publications act as a “mediator” between the original PSL upon which the SL is based and the readers, equipping the audience with likely lacking “external criteria” so that they may better “evaluate the work and put it in its proper perspective” (as cited in Baram-Tsabari & Yarden, 2005, p. 419). This reduction in information gaps is reasoned to allow students better understanding than that from reading PSL (Baram-Tsabari & Yarden, 2005, p. 419). The original canonical manner, “internal logic” and “sequence” of the PSL is removed in Secondary Literature to raise the interest of

readers (Baram-Tsabari & Yarden, 2005, p. 418). Consequently, scientific epistemology is not often well portrayed by media reports, particularly “scientific reasoning and the components of scientific argument” (Norris et al., 2009, p. 406; Ford, 2009, p. 386). Yarden states that the SL text genre provides minimal evidence and false certainty of the facts presented (2009, p. 309). In this case, authenticity is sacrificed for accessibility.

Necessity of SL

Some researchers contend that such “public domain” forms of science literature are those most likely to be encountered by students “in their future lives” (Ford, 2009, p. 386; Osborne, 2009, p. 399). The arguments logical path then leads to a demand for SL/JRV critical reading skill development as part of science curricula, given that students need to cultivate the “will and ability” to critically read and comprehend such text genres in order to become “life-long learners”, in addition to independent, healthily skeptical, productive, and safe citizens (Osborne, 2009, p. 399; Yarden, 2009, p. 309; Baram-Tsabari & Yarden, 2005, p. 422).

Baram-Tsabari and Yarden argue that in order for science education to accomplish such extraordinary goals, “students’ attitudes toward self-directed secondary literature reading” needs to be regarded with “the utmost importance” (as cited in, 2005, p. 422). Any negative association(s) toward the reading and comprehension of scientific text, such as low self-efficacy, will increase the likelihood of such students’ scientific literacy avoidance. Reducing exposure and practice will hinder these students’ chances of improving their ability with scientific texts, sustaining the negative view and skill deficit. Such students will be less capable of responding to science exposures as citizens. In addition, such students are less likely to pursue science related endeavors. Tracking this chain of events from negative scientific text connotation leads to conclusions that are contrary to contemporary science education efforts. It is therefore important

for scientific literacy instruction to consider productive student self-efficacy an incorporated objective.

Traditional Science Classroom Textbooks

Limitations

K-12 textbooks are typically “written by science educators and science writers”, and present science as a certainty, consisting of “facts with minimal evidence to support conclusion” (Yarden, 2009, p. 309). From an analysis of statements within common science textbooks, conducted by Phillips and Norris, 51% to 77% were devoted to providing truths (facts of conclusions), 3% allotted to the way in which research was conducted, and less than 2% allocated to providing some form of reasoning (2009, p. 316). Hence the all too common “use of the present tense – ‘the structure of DNA is a double helix’ and the excision of any tentativeness or conditionality in their statements” (Osborne, 2009, p. 398). Phillips and Norris argue that such a significant misrepresentation results in a “distortion” of science to the point of unrecognizability, leading to incorrect and overly simplified student views of not only science reading and writing, but science overall (2009, p. 316).

Arguably even worse still, this omission of the justification, discovery, and “logical coherence” of science, contrary to the very nature of science, often infiltrates and influences, if not dominates, the context of the classroom (Osborne, 2009, p. 398). Teacher discourse and course reading was often found to be “largely confined to developing vocabulary and descriptive understandings of phenomena and situations” (Norris et al., 2012, p. 634). Such has been argued to result in poor student reading ability of scientific text (Phillips & Norris, 2009, p. 317). Specifically, students tend to exhibit a “certainty bias” greater than that intended by the authors,

a weak interpretation and evaluation of the text's scientific reasoning, a disconnect between their own beliefs about the reading and the textual evidence provided, and a differing in explanation of the text's meaning from what was actually read (Phillips & Norris, 2009, p. 317).

Perhaps of graver concern, the authors observe such underdevelopment continues into and often persists in higher education (Phillips & Norris, 2009, p. 317). College students "hold the same impoverished view of reading as their younger counterparts", rendering the accumulation of background knowledge unable to much improve their interpretation of science texts (Phillips & Norris, 2009, p. 317). These limitations of SL and textbooks resemble many of the current shortcomings of science education that research and reform is attempting to address. This makes sense, given that textbooks and SL are the primary form of scientific text in most curricula. In other words, the quality of scientific literacy instruction and the success of student scientific literacy skill development greatly determines the strengths and weaknesses of the classroom.

Justification

However, given that the majority of science classrooms concentrate on developing student understanding of basic science concepts, texts that provide "consensually-agreed explanatory account[s]", may have their place (Osborne, 2009, p. 398). In addition, it can be argued that foundational understanding and background knowledge accumulation, frequently resembling an established understanding of terminology, is necessary for more complex mastery. In this way, Osborne argues that textbooks should be judged by the quality with which explanations of contemporary understanding is communicated, rather how effectively such is accessed by the intended audience, adolescent students. They should not then be assessed by their provision of competing theories or their accurate portrayal of scientific paths as they truly

unfolded, despite the significance of such qualities to current scientific understanding (Osborne, 2009, p. 398). There is, after all, only so much time an instructor can spend on each concept.

Adapted Primary Literature (APL)

Addressing Science Education Gaps with an APL Bridge

From narrative to expository, the authentic nature of the text increases, while the ease of accessibility to a pre-college student and teacher population decreases. It is this counterbalance that instructors must battle in order for students to understand and reap the benefits of authentic science text experiences. The difficulty for students, and, perhaps teachers, in reading and understanding PSL has resulted in textbooks and SL dominating classroom reading (Norris et al., 2012, p. 634). Consequently, students tend to lack a sense of scientific text genres and familiarity with scientific literacy (Norris et al., 2012, p. 634).

In their 2012 publication, Norris et al. stated that research of science curriculum has indicated “two perennial failures” at the high school level. The first, failed regard for “the nature of scientific reasoning and argument” as systematic and comprehensive, in addition to their connection with “scientific conclusions”. The second, lack of student exposure to some of modern sciences most fascinating and critical ideas, particularly those arising from interdisciplinary examinations (p. 635). Noted by leaders of the field, two substantial gaps in science education are “between real-world science and school science” and “between scientific research and school inquiry learning” (Falk & Yarden, 2009, p. 352). School science and inquiry tend to be simple, superficial, and certain, resulting in the development of cognitive skills far distant from that of real scientific practices (Falk & Yarden, 2009, p. 352).

Recent national standard revisions reflect such areas of concern, calling for more than memorization, “a balance between knowledge and investigation” (Norris et al., 2012, p. 635). The new vision of science education is as “a process of inquiry” for which students create, test, and deliberate alternatives to present scientific research explanations (Norris et al., 2012, p. 635). In addition, changes to standards have included a demand for relevance, the connection of science to students’ familiarities, and demonstration of “the thought processes, assumptions, and evidence scientists” use “to reach their conclusions” (Norris et al., 2012, p.635).

Norris et al. explain that Adaptive Primary Literature (APL) is projected to address these circumstances based upon three qualities. Most notably, APL is focused on the centrality of reading to science learning, resulting in resources for the learning of science that concur with practices as they are conducted by scientists. Second, APL stresses “scientific writing as thoughts interconnected to form completed arguments”, rather than “the reading of isolated scientific terms”. Third, APL contributes a facet of authentic science lacking in ‘hands-on’ aspects (2012, p. 635).

Ford claims APL provides an opportunity for instructors “to scaffold student interactions with some of the uncertainty and messiness of scientific reasoning.” Perfection does not exist in science. For example, with regard to imperfect correlation specifically, authentic science frequently involves the use of “less than perfect” evidence or “data sets” (containing “outliers, anomalies, gaps,” etc.) in the development of convincing claims. Ford argues this truth is difficult to convey through ‘hands-on’ investigations in which students are accustomed to intended success. Students have a tendency to regard the finding of anything except the anticipated result a failure. However, Ford reasons the examination of a scientists reported data

in the written form of APL “can introduce the subtler aspects of argument without interference from typical classroom social dynamics” (2009, p. 387).

Falk and Yarden present yet another way in which APL addresses current science educational needs by supplying “a context that promotes both dimensions of inquiry learning” (2009, p. 351). In another publication, Yarden carries on to explain that APL is a valuable tool to “represent ‘real science’ in schools”, aiding students in the development of scientific literacy skills, such as argumentation and reasoning, far better than textbooks or SL (2009, p. 309). Generally speaking, APL is an effective tool to bridge academic secondary science and professional science so that current students may be prepared to contribute to a better future.

APL Design

Adapted Primary Literature (APL) is a relatively novel text genre that resides toward the center of the previously discussed spectrums of scientific texts, possessing reasonable accessibility and preserved authenticity. APL consists of articles adapted from PSL, most “often by science writers and reviewed by scientists” (Norris et al., 2009, p. 322; Falk & Yarden, 2009, p. 350). APL is created to maintain “the canonical form” or structure of the original document to the greatest extent possible, yet reasonably match the cognitive and “comprehension level” of adolescent science students (Norris et al., 2009, p. 322; Falk & Yarden, 2009, p. 350). The conserved “organizational structure” of data-based papers referred to, common among “diverse disciplines”, entails the following with regard to observation generated data: presentation, demonstration of relevance to the scientific problem, description of “collection and analysis methods”, and interpretation (Norris et al., 2012, p. 636). Extrapolating on the latter, the identification, acknowledgement, and, if appropriate, impeachment of alternative interpretations

is also included (Norris et al., 2012, p. 636). Worth noting, PSL's "theoretical in nature" likely possess a "different canonical form" (Norris et al., 2012, p. 636).

Due to the structural similarity of "scientific writing and scientific method," APL is promising "as an organizer for students' scientific thinking" (Baram-Tsabari & Yarden, 2005, p. 419). Phillips and Norris add that APL conveys a crucial feature of scientific writing, one that the authors urge should be a goal of science education - justification of arguments to support conclusions (2009, p. 316). In this way, students are less perplexed and intimidated by the origin of scientific understanding (Phillips & Norris, 2009, p. 316). Researchers confess that any alteration, however minimal, to the "jargon and technical language" of the original PSL is likely to impact authenticity, as such were selected by the authors for a reason, to convey an exact meaning that may not be preserved by any substitution (Norris et al., 2009, p. 322). However, research results thus far have demonstrated support for APL as a more authentic and accessible combination text genre than others currently available.

Defended By Research

Baram-Tsabari & Yarden examined the inquiry skill and comprehension effects of separate Israeli student groups, each varying in degree of prior knowledge in biology, reading one of two randomly assigned text genres (ADP or SL) based on a "breakthrough research article" (PSL) about "a polyvalent inhibitor to the anthrax toxin". The topic was selected for its authenticity and potential to elicit student interest, due to popularity in current events, standing as a current real-world issue, and interdisciplinary incorporation of science, technology, and society (S-T-S). The content of both texts was designed to be as identical as possible in order to analyze results in terms of text structure only. The researchers found superior demonstrations of inquiry skills by APL readers than those who read the secondary literature version, while students that

read the secondary literature genre had greater comprehension and better attitudes toward the text than those who read the adapted primary literature (2005, p. 418).

To determine the generality of the Baram-Tsabari and Yarden results, Norris et al. performed a similar study in Canada (2012). Mirroring the original research to the greatest extent appropriate for comparison, Norris et al. achieved similar but not identical results. The Canadian study found that APL possess' a substantial benefit over SL in terms of "one sub area of scientific inquiry, critical thinking." Recall Baram-Tsabari and Yarden found an overall scientific inquiry advantage for APL. The confirming authors argue that this result corresponds to the work of "other studies that have successfully utilized the primary literature format as a means to increase critical thinking." In comparison to the APL students, Norris et al. found better summary questionnaire performance for SL students, while Baram-Tsabari and Yarden found a true false questionnaire advantage for SL students. However, despite this discrepancy, both questionnaires were measures of student text comprehension.

Norris et al. state they "cannot conclude with confidence that" their "results differ" from those of Baram-Tsabari and Yarden, explaining the possibility of each study's numerous factors individually impacting critical thinking differently, but "with the net effect being the same." The authors urge for more research to conclude the effects of various scientific text genres on the thinking and comprehension of adolescent students (Norris et al., 2012, p. 643-645). Although differences were found at multiple levels, the results are promising; the almost duplicate effect on critical thinking of both studies suggests student experience with "texts that resemble canonical scientific form" have the potential to elicit the utilization of "critical thinking skills" already present. Furthermore, Norris et al. argue that the distinct locations of both studies

suggests such results “can occur across different cultures, languages, student ages, science topics, and other contextual differences” (2012, p. 645).

Discussion

Implementation Recommendations and Cautions

A study of an APL based biotechnology curriculum, conducted by Falk, Brill, and Yarden, began the realization that different sections of an APL are associated with different student difficulties (2008). The authors found that the Methods and Discussion sections posed the greatest challenges for students, the Methods likely due to its “abstract nature” and required application of prior knowledge for comprehension, the Discussion likely for questions that challenge reader confidence in text understanding. (Falk et al., 2008).

Arguing that the Methods and Results sections both deal in the “particulars of [a] study”, Falk and Yarden sought to further examine the work of the 2008 publication by analyzing the specific student difficulties and the corresponding optimal “epistemic practices” associated with the differing “genres and roles of the Results and Discussion sections” of a biotechnology APL (2009). They found that application of the enactment model to the Results and Discussion sections of APL allows students to develop both inquiry dimensions (*as* inquiry and *by* inquiry) and “scientifically authentic epistemic practices” (2009, p. 380). The authors also recognized “the emergence of a rich variety of coordination practices”, explained to have resulted from the synergistic effect of both reading and scientific research associated coordination (Falk & Yarden, 2009, p. 380).

Falk and Yarden continued researching the differing student and instructional challenges associated with APL sections, in addition to investigating possible strategies for overcoming

them, by examining the teaching and learning of an APL's opening sections in terms of three different models: the conversational model, the problem-solving model, and the scientific literacy model (Falk & Yarden, 2011). For this study, the opening sections refers to the Title, Abstract, and Introduction. An APL conserves the purpose and comprehension level of the original PSL opening sections, with the Title and Abstract serving as a succinct summarizing of the research and the Introduction connecting the research to other experiments of the domain. The authors chose to focus on instruction of the opening sections due to three concerns that arose from conversations with teachers reluctant to incorporate APL into their classes. The first, intimidation of students from a "sudden exposure to an overwhelming amount of novel terms and ideas". The second, prioritizing of content over inquiry and NOS as a result of text challenges. The third, instruction reversion to teacher-centered approaches in an attempt to aid student comprehension challenges (Falk & Yarden, 2011, p. 78).

The conversational model "is based on a teacher-mediated constructivist dialogue between the students and the article" (Falk & Yarden, 2011, p. 78). The instructor provides students the necessary guidance to increase their questions in sophistication and research orientation (Falk & Yarden, 2011, p. 79). With students guided to expect answers to their questions through further reading, the process becomes a reading inquiry (Falk & Yarden, 2011, p. 79). However, feedback has indicated this model's stages can render it "time-consuming" and "tedious" (Falk & Yarden, 2011, p. 81).

The problem-solving model begins prior to student exposure to the APL, by presenting students with a problem akin to that of the APL and asking for a reasonable methodology and experimentation that addresses it (Falk & Yarden, 2011, p. 79). Students collaboratively utilize their prior knowledge, inquiry skills, and any relevant information provided by the instructor, as

the teacher guides student suggestions toward superiority, if necessary, providing opposition supported by “practical and experimental limitations” (Falk & Yarden, 2011, p. 80). It is important to be aware that this model has a tendency to allocate greater weight of the knowledge provider role to the instructor than the article (Falk & Yarden, 2011, p. 81).

The scientific literacy model is more flexible in structure than the other two, including student exposure to different text genres presenting the same scientific concept (Falk & Yarden, 2011, p. 80). In the case of this study, two different popular media reports represented the scientific topic in a narrative genre of simple language, aiding comprehension, while an APL article of the same topic provided the detail necessary for inquiry (Falk & Yarden, 2011, p. 80). The sequence of exposure is flexible (Falk & Yarden, 2011, p. 80). The popular text could be introduced first to establish a general baseline of understanding and elicit higher-level questioning, to be addressed by the APL that follows (Falk & Yarden, 2011, p. 80). Or, students could achieve scientific understanding by first reading the APL and then comparing the popular media report in order to emphasize recognition of the latter genre’s misrepresentations: exaggerations, shortcuts, analogies, personifications, etc. (Falk & Yarden, 2011, p. 80). Whichever format is chosen, a primary objective is comparison among different text genres: the audience, the depth of information provided, the NOS aspects included (Falk & Yarden, 2011, p. 80). Exposing the discrepancy between popular science and the origin will result in students developing the critical reading skills necessary to become successful and safe citizens. Unfortunately, it can be difficult to find different text genres on the same concept that are appropriate for the instructor’s needs (Falk & Yarden, 2011, p. 81).

Multiple models can be used together in order to reap the benefits and minimize the limitations of each (Falk & Yarden, 2011, p. 81). For example, the conversational model or

problem-solving model could be used for the reading of the first article in the scientific literacy model (Falk & Yarden, 2011, p. 80). The authors state they do not favor one model over the other two, as each addresses different valuable scientific skills (Falk & Yarden, 2011, p. 81).

Additional Application Recommendations and Cautions

Content selection for the APL is critical in terms of the success and value of such a text implementation to desired educational objectives. Ideally, APL chosen topics should hold a balance among “diverse demands”: “standards-based topical constraints,” adapted science accessible to students, engaging and motivating, and demonstrate “authentic scientific practice” (Ford, 2009, p. 388).

Not a concern unique to APL, but “any curricular innovation”, is supplying the necessary supports for teachers (Ford, 2009, p. 388). There are a great many demands placed on a secondary teacher of science, including strong content understanding, nature of science practice awareness, current in scientific research, and “literacy instruction techniques” (Ford, 2009, p. 388). There is concern regarding high school science content specialist teacher preparation to perform the latter, and all that it entails (Ford, 2009, p. 388). Successful reading comprehension of a science text entails more than facts, but “activation of multiple knowledges of content, text structure, author intent and the like” (Ford, 2009, p. 388). A lack of confidence with “APL associated Pedagogical Content Knowledge (PCK)” can result in instructor reluctance to incorporate APL (Yarden et al., 2009, p. 393). In addition, Falk et al. found that that instructor APL associated PCK is crucial to enactment success (2008). Ford suggests “a research-based pedagogy of science reading inquiry” to increase instructor willingness to incorporate APL into their instruction and the success with which they do so (2009, p. 388).

Yarden et al. offer four supports utilized for their research and applicable to more general aid considerations. The authors label this list the “tip of the iceberg” as to what is necessary for the vision to be realized: the vision being the utilization of APL to address secondary school’s necessity for authentic inquiry. One support, an “enactment model based on a constructivist dialogue between the students and the article, with mediation” from “the teacher.” Another, a “multimedia curriculum guide” including a question and task pool for instructor selection based on suitability to purpose, students, class, and needs, along with “video-taped class enactment sequences, accompanied by pedagogical comments” for the scaffolding of student performance expectations, teaching plans and strategies. A third, varied forms of professional development workshops: acquaintance, summer, and follow-up. And finally, the fourth, a web site equipped with pictures for teacher presentations, animations for methods instruction, and a forum to ask questions and share materials (2009, p. 393-394).

The authors express their hope that these recommendations alleviate teacher concern, resulting in greater APL implementation, and improve teacher effectiveness with APL instruction so that science education objectives are better met. In addition, the authors encourage the design of other models, including modification and personalization of those provided here, and continued research to improve APL success.

From Here – Suggestions for Further Research

The research and corresponding results presented and analyzed here primarily involved implementations of APL content from the biology discipline, with interdisciplinary associations such as mathematics and technology. Further studies are needed to determine if the results found to justify APL with biological content are expandable across the science disciplines, given “discipline specific epistemologies” (Ford, 2009, p. 388).

As with most implementations at the secondary level, an “overarching learning progression” across K-12 that gradually builds the development of skills to be called upon in science discipline courses and beyond allows for greater practice, exploration, and extension prior to graduation (Ford, 2009, p. 388). For years, curriculum development has included a focus on the organization of fundamental scientific knowledge “into grade to grade sequences that” reflect and aid in a process of increasing student “understanding and sophistication” with age (Yarden et al., 2009, p. 392). Further research is needed to determine what scientific text characteristics might be a suitable precursor to APL engagement at the secondary level (Ford, 2009, p. 388). Ford recommends incorporating literature into science learning in order to establish the normal role of reading and writing, in addition of ‘hands-on’ components, to scientific inquiry (2009, p. 388). Ford also predicts that successful incorporation of APL at the secondary level could result in opportunities for PSL incorporation later on, perhaps more likely in advanced coursework (2009, p. 388). In addition, student practice with the elevated sophistication of APL content and structure may better prepare students for college and/or career text reading and writing requirements.

Admittedly, greater research of the nuances associated with APL effectiveness and implementation is needed before any concrete conclusion or curriculum design alterations are made. Still, these research results show great promise that adapted primary literature has great potential to equip students with the “variety of tools and skills that a future citizen and decision-maker should possess” (Baram-Tsabari, 2005, p. 422). APL “has the ability to introduce complex, authentic, and cutting edge examples of actual scientific arguments to high school learners”, in addition to assisting student understanding of the various ways in which scientific ideas may be communicated (Ford, 2009, p. 388).

Conclusion – A Call for Balance

This defense of APL is not advocating for the replacement of other forms of science text instruction, but, rather, to encourage a balanced curriculum in which the plethora of science texts are incorporated. Exposing students to the diversity of scientific text genres allows for the development of skill with the “varied processing” elicited by each type (Baram-Tsabari & Yarden, 2005, p. 405; Ford, 2009, p. 386). Text is “central to any understanding of science” (Osborne, 2009, p. 402). Therefore, assisting student reading of science texts – whether textbooks, APL, or SL – should be included in any science education (Osborne, 2009, p. 402). The unique lessons offered by each scientific text genre can be regarded “as complementary” (Norris et al., 2009, p. 406 & 409). It is important to be capable of both comprehending science’s epistemology and reading popular scientific news reports (Norris et al., 2009, p. 406 & 409). Therefore, the text genres that best address each, APL and SL respectively, should hold a place in allocated literacy instruction. Field experts argue that curricular time “can be found for both by reducing the overwhelming amount of factual content” (Norris et al., 2009, p. 406 & 409).

Baram-Tsabari and Yarden propose wrapping APL suitable for the given students’ cognitive level, in order to improve NOS inquiry understanding, within a SL “package of popular-scientific articles”. Both the APL and SL, in this case, are of the same topic so that the SL articles may partially compensate for information holes present within the APL. Such a design is intended to allow students lacking parts of required prior knowledge an enhanced understanding; provide missing outside measures necessary for an evaluation of text’s implications; and improve student “attitude toward self-directed” SL reading for further science participation in the future. Baram-Tsabari and Yarden support the potential of this framework to

nurture an interaction between APL and SL, creating “a well-informed future citizenry” (2005, p. 422).

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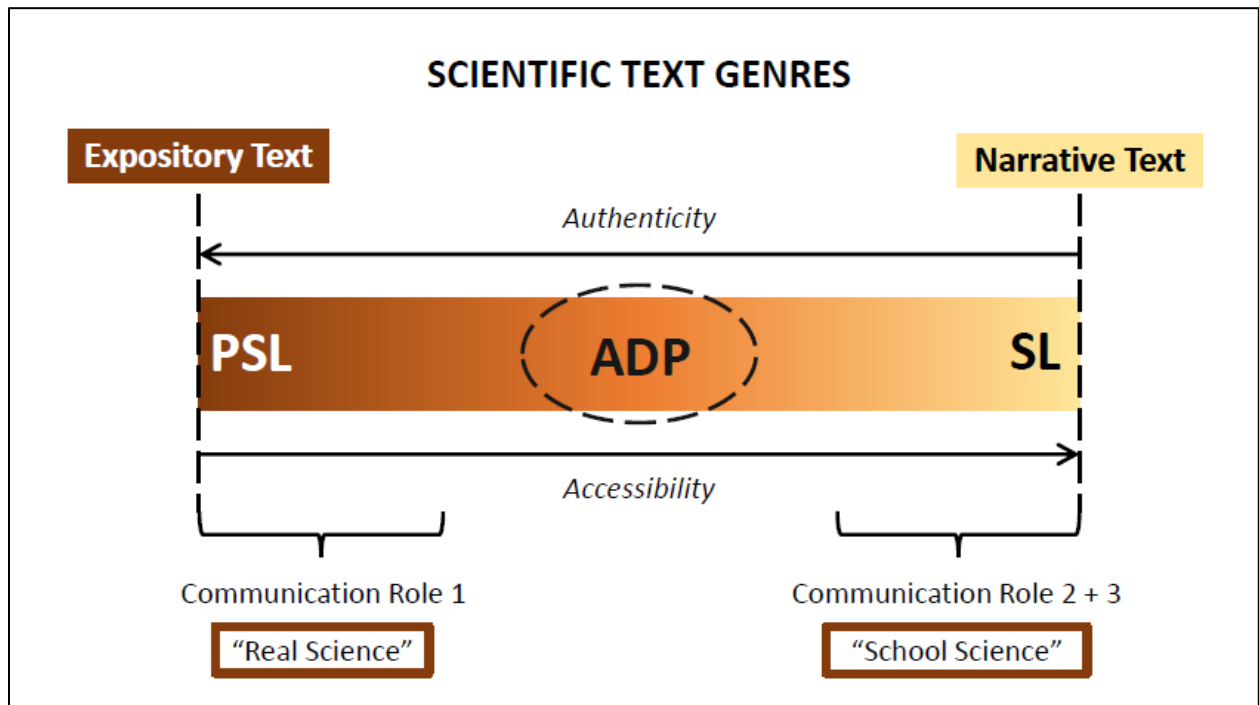
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Appendix A

Scientific Text Genres



Adapted Primary Literature (APL): Sample 1 - Impact of Human Noise

Lauren Thresh
The College at Brockport

Original Primary Literature (PL) Source:

Mason, J. T., McClure, C. J. W., & Barber, J. R. (2016). Anthropogenic noise impairs owl hunting behavior.

Biological Conservation, 199, 29-32. <http://dx.doi.org/10.1016/j.biocon.2016.04.009>

NYS Standards:

The Living Environment Core Curriculum, The University of the State of New York, The State Education Department, <http://www.nysed.gov>

Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

- 7.1c Human beings are part of the Earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.
- 7.2a Human activities that degrade ecosystems result in a loss of diversity of the living and nonliving environment. For example, the influence of humans on other organisms occurs through land use and pollution.
- 7.2b When humans alter ecosystems either by adding or removing specific organisms, serious consequences may result.
- 7.2c Industrialization brings an increased demand for and use of energy and other resources including fossil and nuclear fuels. This usage can have positive and negative effects on humans and ecosystems.

Anthropogenic noise impairs owl hunting behavior

The **Abstract** is a brief summary of the article to come, often containing:

- Purpose / rationale of study (*why was this study done*)
- methodology (*how was this study done*)
- results (*what was found – in brief*)
- conclusion (*what do the findings mean and why does it matter – in brief*) [1]

ABSTRACT

The evidence of recent studies has shown that **anthropogenic** noise is negatively impacting natural communities (plant and animal). Yet, the impact of such noise on predators that use sound to hunt is less studied. The results of this experiment show that the noise from natural gas compressor stations negatively effects the hunting success of saw-whet owls (*Aegolius acadicus*)

argumentative text structure

Anthropogenic – from human activity, primarily from environmental pollution

Latin species names – written in italics, first letter of first name capitalized, the second name all lowercase

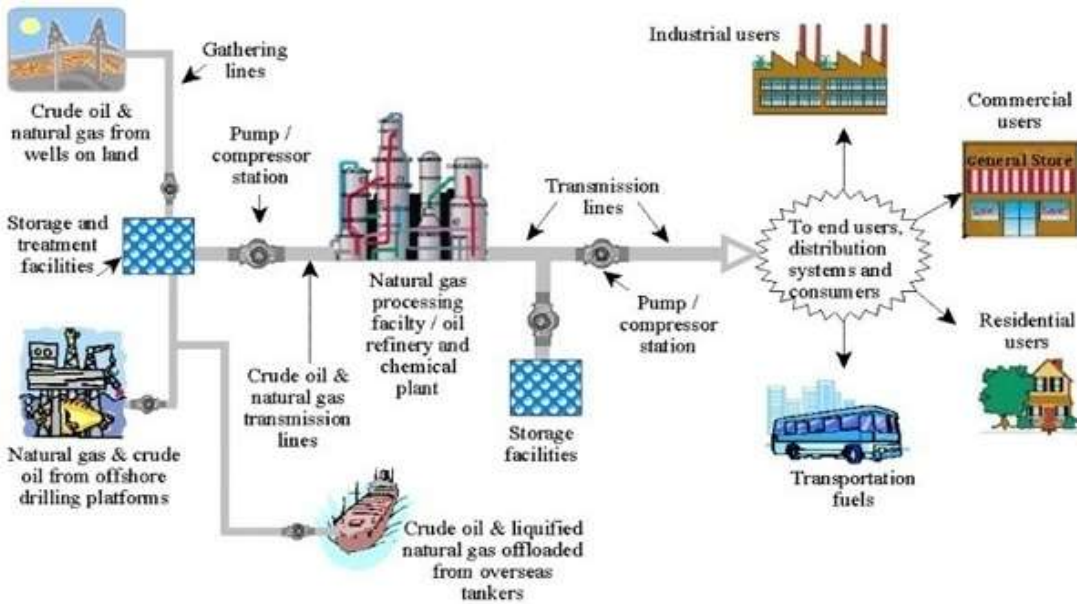
Natural Gas Compressor Station:

Compressor stations (facilities) assist in the transport of natural gas from one location to another so that the gas may be delivered to its destination. More specifically, special turbines, motors, and engines of the compressor stations perform the essential task of compressing / pressurizing (increasing the pressure of) the natural gas, providing energy to move the gas through the pipeline. The number of compressor stations located along a pipeline depends on numerous factors: pipe diameter, volume (amount) of gas to be moved, and terrain of surface gas moved across. [3]

Saw-Whet Owl:



small, North American native [4]



U.S. Department of Transportation: Pipeline & Hazardous Materials Safety Administration. (2011, December 1). Fact sheet: Pump and compressor stations. Retrieved from <https://primis.phmsa.doi.gov/comm/FactSheets/FSPumpStations.htm>.

sample size

For this study, 31 saw-whet owls were caught from the wild and placed in a tent with their prey (mice). The tent was designed for avian flight and was given a field setting. The acoustic (sound) conditions within the tent mimicked those produced by a

environment of saw-whet owls captured

compressor station (50-800 m). Two **hypotheses** were developed to assess how such noise affects hunting. The first, as the noise level increases, the negative impact on hunting increases (the dose-response hypothesis). The second, all noise levels tested will produce equal impact on hunting or no impact at all (the threshold hypothesis). The **dependent variables** tested in this study were overall hunting success and each step of the attack (prey detection/discovery, strike, and capture). The results of the experiment support the dose-response hypothesis. As the noise level increased (per decibel), hunting success decreased by 8%, prey detection decreased by 11%, and strike behavior decreased by 5%. In other words, these results show that **unmitigated** noise can decrease the hunting success of **acoustically specialized predators**, reducing survival and reproductive success (the likelihood of producing offspring). This will decline the presence of such predatory species in these noisy habitats. The loss of predators is likely to have a ripple effect on the **ecosystem** to which it was part.

Unmitigated – not reduced or lessened

Acoustically specialized predators – species that have evolved to hunt using specific sound techniques

Ecosystem – a community of interacting organisms and their environment

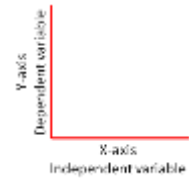
What is this study about?

environmental constant for more reliable comparison between noise and quiet

Hypothesis – proposed explanation to be tested

Dependent Variable – often represented with ‘y’ and on the y-axis of a graph, dependent on another variable (or the independent variable), the observed, the effect

Independent Variable – often represented with ‘x’ and on the x-axis of a graph, what the scientist changes, the cause



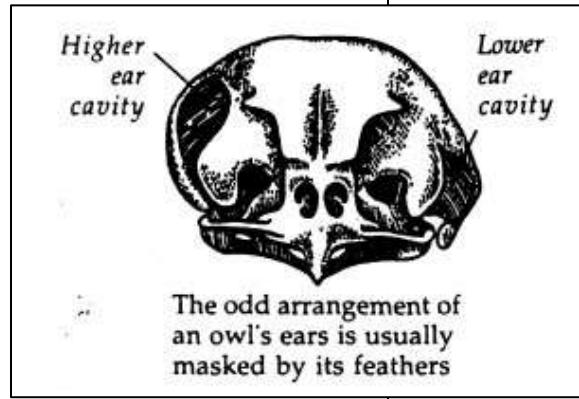
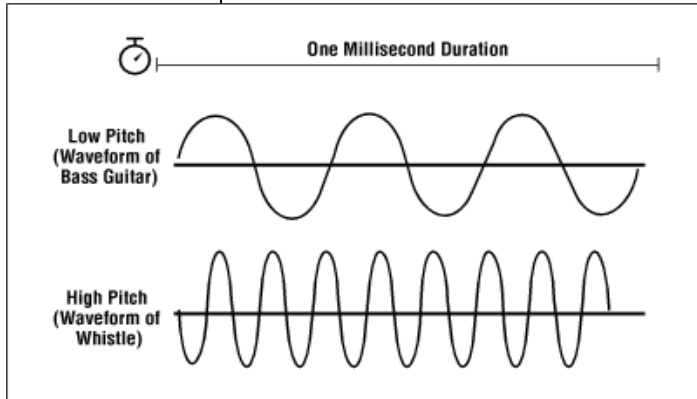
INTRODUCTION

Recent studies have found that anthropogenic noise impacts animal behavior, distribution, and reproductive success. For example, size and variety of songbird species populations have been found to decrease by one-third at loud compressor stations compared to quiet sites still at natural gas extraction fields. Yet another example, traffic noise has been found to reduce the presence of songbirds while other species almost completely avoid such areas. Yet lacking is information from the examination of how noise affects predators that rely on sound to hunt. Studies conducted within laboratories found that acoustic (sound) conditions matching those of a highway (50 m) caused

The **Introduction** is... the background, what is known about the topic, what is not known about the topic, previous work, current understanding of topic examined / studied, question want answered [1]

Echolocation - the bat emits a high frequency call and listens to returning echoes that bounce off prey and landscape, creating a map.

bats to increase their prey search time 2-fold. While bats use high-frequency acoustic information to hunt, owls use low-frequency. Lower frequency has a larger wavelength and travels farther than higher frequency. Therefore, the owl may be more vulnerable to human noise across larger distances, resulting in a greater overall impact.



Lasbury, Mark. (2011, September 28). As many exceptions as rules. *Blogger*. Retrieved from <http://biologicalexceptions.blogspot.com/2011/09/do-you-have-be-ugly-to-hear-well-owls.html>.

Vesely, Sophia. Sound: The relationship between pitch and frequency. *Weebly*. Retrieved from <http://sophiakeatonsound.weebly.com/the-relationship-between-pitch-and-frequency-of-a-sound-wave.html>.

The ear **asymmetry** of birds is critical for their sound detection ability. Although owls have sensitive visual systems (good sight), they may not be able to see their prey under snow, vegetation, or dark conditions. Therefore, owls have developed sensitive hearing to locate their prey. The more sensitive the hearing, the better able the owl is to find prey, survive, and reproduce. Ear asymmetry has **evolved** independently (separately, isolated) at least 4 times in owls, with the saw-whet owl possessing the greatest degree of ear asymmetry of any known owl. Therefore, the saw-whet owl is a good candidate for this study focused on the impact of human noise on acoustically specialized avian predators.

Asymmetry – unequal, lack of symmetry

Evolution – a theory, a generation interval

Evolution of Owl Hearing, At a Glance:

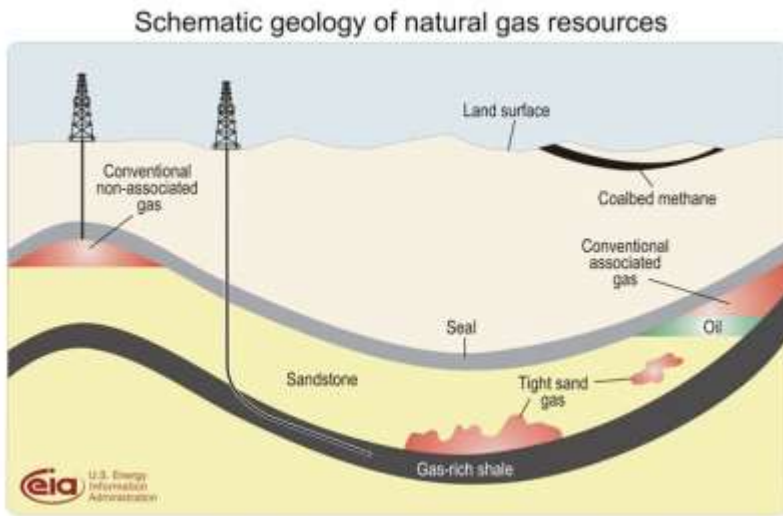
As the result of genetic mutation and/or variation (at the DNA level), an owl with superior hearing ability will hatch. This owl will be better at locating prey, outcompeting other owls for limited resources (prey). This will result in better survival, health, and therefore, more offspring. Some of those offspring will inherit their parent's superior hearing. Those offspring will better hunt, survive, and reproduce too. After generations, superior hearing will increase throughout the population, with

more owls possessing the sensitive hearing trait. Then, with another genetic mutation and/or variation, an owl will hatch that has even superior hearing still, outcompeting the others for resources. Resulting in a greater number of offspring. And the cycle continues, resulting in overall highly sensitive hearing in owls.

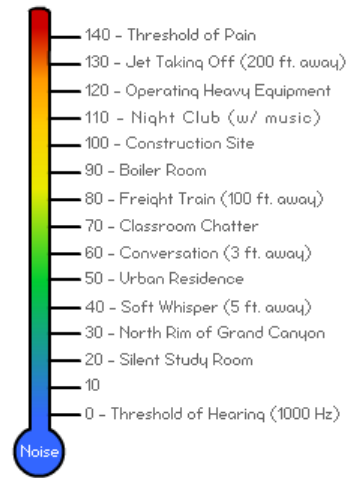
Chronic – persistent, constant, recurring, long-standing, long-term

Ambient - surroundings

Saw-whet owls encounter **chronic** noise from compressor stations that can reach above **ambient** background and across an entire natural gas field. At this time, it is not known if noise affects owl hunting behavior.



Typical Sound Levels (dBA)

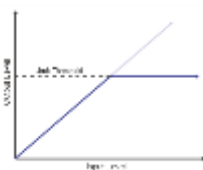


eia: U.S Energy Information Administration. (2011, February 14). Today in energy: The geology of natural gas resources. Retrieved from <http://www.eia.gov/todayinenergy/detail.php?id=110>.

For this study, 31 saw-whet owls hunted mice (*Mus musculus*) in a field setting flight tent with sound conditions replicating those from a compressor station (50-800 m or 46-73 dBA). Two hypotheses were created and compared. The dose-response hypothesis predicted that owl hunting success would decrease with conditions closer to the compressor stations (greater noise). The threshold hypothesis predicted that all of the sound levels tested in this experiment would result in the same negative impact on hunting, as all of the sound levels would be above the **threshold**. Hunting success and the predatory attack sequence (prey detection / finding, attempted prey capture / strike, and successful prey capture) were defined and specified in order to

Driscoll, Dennis P. OSHA technical manual: Section III: Chapter 5: Decibel scale. United States Department of Labor. Retrieved from https://www.osha.gov/dts/osta/otm/new_noise/.

Threshold (in the case of this study) – a magnitude or intensity level that, once exceeded, produces a consistent result



determine the exact areas of owl **predation** affected by human noise. A better understanding of human noise's impact on predators is essential to revealing the full consequences of human noise on ecosystems, predicting likely future changes to the environment, and developing plans to correct negative changes.

Predation – the preying of one animal on others, the action of attacking

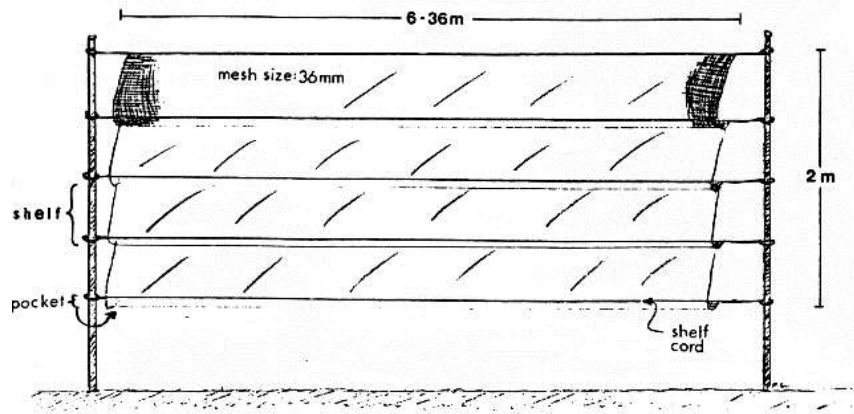
MATERIALS AND METHODS

The Materials and Methods section answers the question:
How was the experiment done?
[1]

- Compressor Station Noise Recording:
 - o Noise from a compressor stations (Gobbler's Knob Compressor Station, WY) was recorded as files to be played back during the study trails
 - o Noise was recorded between 2100-0400 hours (10-12 degrees C) and at distances of 50-500 m from a compressor station
 - o The noise emitted / produced by the station was recorded with a Sennheiser ME66 microphone (40-20,000 Hz; + 2.5 dB) and Roland R-05 recorder (sampling rate 824 kHz)
- Capture:
 - o Intermountain Bird Observatory personnel captured the owls with mist-nets

experienced / trained individuals to minimize injury to the owls

- Mist-Nets:
- used by ornithologists and bat biologists to capture birds and bats for research
 - typically a nylon or polyester mesh of varying sizes suspended between two poles like a volleyball net
 - horizontal lines create a loose pocket
 - not visible to owls
 - owls fly into them, fall into a pocket and become tangled
 - intended to minimize injury to birds/bats
 - permit required to purchase and use [2]



RIC. (1998). *Inventory Methods for Bats*. (Vol. 2). The Province of British Columbia: Resources Inventory Committee. Retrieved from <https://www.for.gov.bc.ca/hts/risc/pubs/tebiodiv/bats/assets/bats.pdf>.

– Flight Tent / Study Environment:

- The flight tent (8 x 7 x 4 m) was light-proof and located ~1 km from the trap site (location from which owls were caught)
- Mice were introduced through one of two possible entry tubes (chosen randomly) that led the mouse to an elevated runway covered in soil and fir needles
- The owl was provided a perch (1.7 m high and 0.4 m wide) located 2.5 m from the runway

– Acclimation Period:

- The owls were given a one-night acclimation period before the study began in which the tent was illuminated with visible light (head lamp)
- This was to allow the birds to become familiar with their surroundings

– Trials:

- The experiment was done at night and without light the owls could see (5 infrared LED arrays)
- The noise condition of each hunting opportunity was randomly selected and played through Bose speakers (Freespace 51, 250 Hz-12 kHz \pm 3 dB) powered by a Kicker (1X500.2) or Lepai amplifier (LP-2020A)
- Each trial took place at night and consisted of 4 consecutive hunting opportunities over 2-3 nights

– Data Collection and Analysis:

- All trials were filmed with infrared-sensitive Canon XA-10 and Sony CX-7 video cameras (high definition, 30 fps)
- Videos were analyzed using Adobe Premiere Pro (CS6)
- Hunting success and components / parts of hunting sequence defined and examined independently:

Light-proof so that the light conditions inside the tent could be controlled and changed by the experimenters

to minimize travel time and disorientation of the owls, to keep as many other variables consistent as possible so that results of study are more reliable

Study Trial – one sequence, attempt within study, test interval

darkness to mimic normal hunting conditions of the owls

noise supply created an even sound field of \pm 2 dBA throughout the hunting area

alone, separate from other hunting behaviors

randomization (random selection) to eliminate bias during study that could influence the results, resulting in more reliable results

reducing the impact of disorientation on the study results (reducing possible variables but those examined by researchers)

used so that researchers could see and examine hunting

filming did not produce light visible to the owl (darkness maintained)

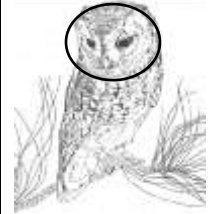


Extraneous – external, separate

additional factors that could have influenced the results were examined

- Mouse detection by owl – owl’s facial disc directed toward mouse for at least one video frame
 - Strike – owl left perch to catch mouse
 - Capture – owl successfully caught mouse
- **Extraneous Variables:**
- Trial order
 - Night of trial
 - Mouse movement
 - Year (study was done in 2012 and 2013)

Facial disc:



Variable – a quantity or quality that varies

Independent Variable	Dependent Variables	Controls
– Compressor Station Noise	– Hunting Success – Hunting Sequence: – Prey Detection – Strike – Capture	– Owl Species – Owl Capture Method – Prey Species – Study Location / Setting

RESULTS

The **Results** section presents what was found (data, calculations, graphs, tables) [1]

- 2012: 12 owls, 32 trials total
- 2013: 18 owls, 152 trials total
- No relationship was found between noise level and mouse movement
- Odds of hunting success decreased by 8% (CI 4%-11%) for each **decibel** increase in noise
- Odds of owl detecting a mouse decreased by 11% (CI 7%-16%) for each decibel increase in noise
- Odds of a strike decreased by 5% (CI 5%-6%) for each decibel increase in noise
- Odds of mouse capture decreased by 9% (CI 2%-16%) for each decibel increase in noise, 11 times less likely to capture a mouse with all noise levels compared to control conditions

noise level did not influence mouse movement

Hunting Success, Prey Detection, and Strike variables support dose-response hypothesis

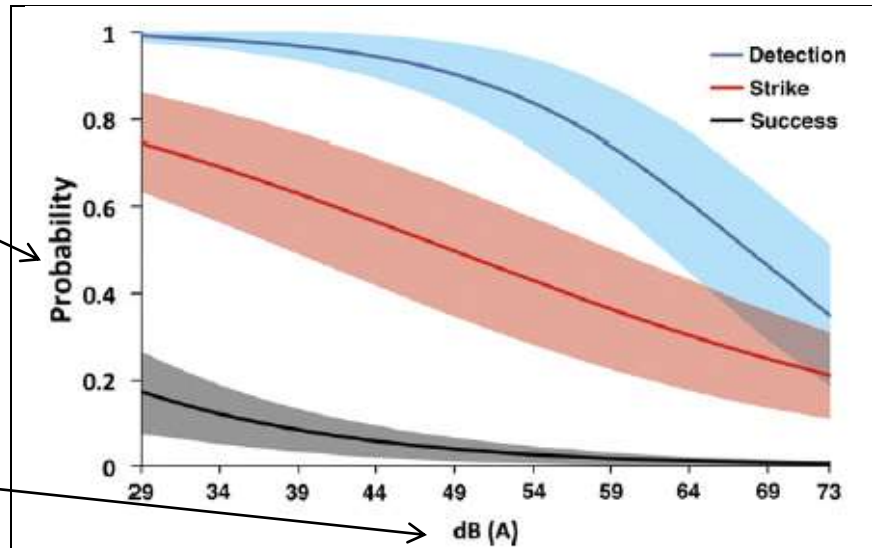
only the capture variable supported both hypotheses (threshold and dose-response)

Decibel – unit of sound intensity

Control conditions – no noise

Y-Axis / Dependent Variable -
Likelihood of variable (prey detection, strike, hunting success) occurring

X-Axis / Independent Variable (changed / set by researchers) – compressor station noise level



Shaded area of graph represents standard error...
There is always some degree of error in any experiment, as human skills are imperfect (human error). Animals are also imperfect and the environment is ever changing, further creating possible error.

The **Discussion** section covers the... conclusion, significance, meaning, context in broader scope, answer to posed question (hypothesis supported or not supported) [1]

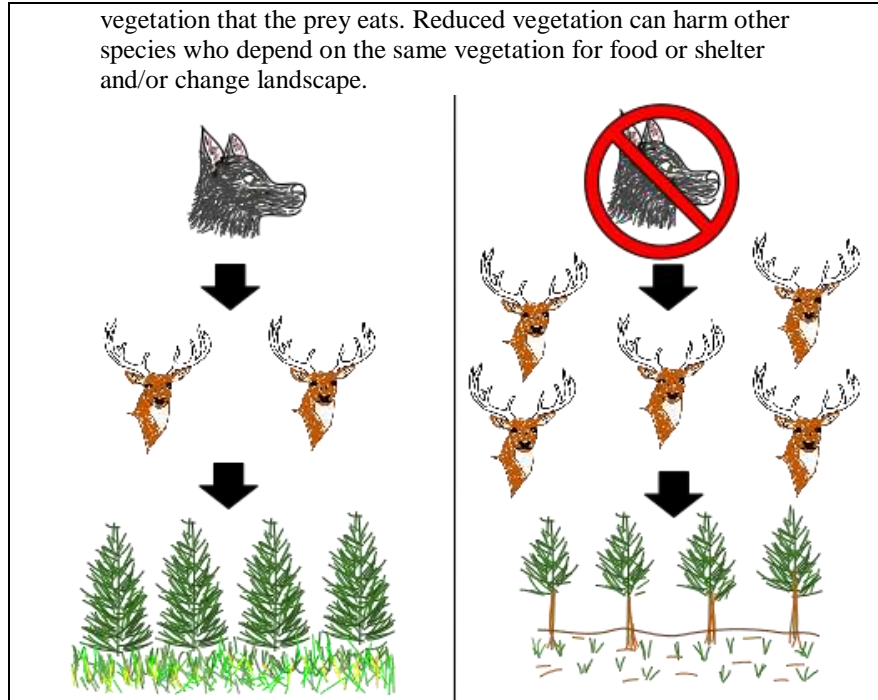
DISCUSSION

A saw-whet owl's ability to successfully hunt, detect prey, and strike prey decreased with increasing noise level. The presence of any additional noise negatively impacted a saw-whet owl's ability to capture prey after a successful strike. Above 61 dB(A), no mice were captured. Noise likely interferes with the owl's ability to gather and/or process sound information from prey, a critical aspect of hunting for owls (acoustically specialized predators). Compressor station noise of 50-200 m overlapped the sound of mouse footsteps. Hence the owls of this study did not successfully catch mice within these noise levels.

Between year 2000 and 2012, an average of 50,000 new gas wells were drilled each year. Although no studies have examined the presence of owls around these areas, the results found here suggest that the noise from such structures may drive owls out of otherwise suitable habitat, or harm their condition (health) should they remain. A change in a top predator will likely impact the ecosystem to which the owl was part.

Trophic Cascade:

The absence or reduction in a predator can cause an increase in the population of its prey. This in turn causes a reduction in the



Trophic Cascades. Retrieved from <http://www.geo.hunter.cuny.edu/tbw/trophic.cascade/index.htm>.

ARGUMENT

Human acoustics (noise) should be mitigated (lessened) and managed in order to reduce harm to the environment. For example, noise walls surrounding compressor stations should be implemented (put into place) to reduce the noise that is released into the surrounding areas.

Further research is needed to determine...

- the impact of compressor stations on owl populations (size and health) of surrounding areas
- changes occurring in ecosystems surrounding compressor stations as a result of the station's noise affecting owl populations
- predator and prey relationships vulnerable to human noise and how those trophic connections are being changed
- the overall impact of human noise on ecosystems

Trophic Connections – relationship between trophic levels of an ecosystem

Trophic Level – organisms of an ecosystem that share the same place within a food chain

It is common for further research suggestions to be presented toward the end of the article. No one study answers all possible questions on a topic completely. Further investigation, examination, and study is always needed.

References

- [1] *Duke University: Medical Center Library & Archives*. (2016, July 7). Scientific writing: Sections of a paper. Retrieved from <http://guides.mclibrary.duke.edu/scientificwriting/sections>.
- [2] Keyes, Brian E., & Grue, Christian E. (1982). Capturing birds with mist nets: A review. *North American Bird Bander*, 7(1), 2-14. Retrieved from <https://sora.unm.edu/sites/default/files/journals/nabb/v007n01/p0002-p0014.pdf>.
- [3] *STI Group*. (2014, January 21). Compressor stations: What they do, how they work, and why they are important. Retrieved from <http://setxind.com/midstream/compressor-stations-what-how-why/>.
- [4] *The Cornell Lab of Ornithology: All About Birds*. (2015). Northern saw-whet owl. Retrieved from https://www.allaboutbirds.org/guide/Northern_Saw-whet_Owl/id.

Adapted Primary Literature: Sample 2 – Taurine in Cats

Lauren Thresh
The College at Brockport

Original Primary Literature (PL) Source:

Stratton-Phelps, M., Backus, R. C., Rogers, Q. R., & Fascetti, A. J. (2002). Dietary rice bran decreases plasma and whole-blood taurine in cats. *Journal of Nutrition*, 132(6), 1745S-1747S.

<http://jn.nutrition.org>

NYS Standards:

The Living Environment Core Curriculum, The University of the State of New York, The State Education

Department, <http://www.nysed.gov>

Key Idea 1: Living things are both similar to and different from each other and from nonliving things.

- 1.2h Many organic and inorganic substances dissolved in cells allow necessary chemical reactions to take place in order to maintain life. Large organic food molecules such as proteins and starches must initially be broken down (digested to amino acids and simple sugars respectively), in order to enter cells. Once nutrients enter a cell, the cell will use them as building blocks in the synthesis of compounds necessary for life.

Key Idea 5: Organisms maintain a dynamic equilibrium that sustains life.

- 5.2h Disease may also be caused by inheritance, toxic substances, poor nutrition, organ malfunction, and some personal behavior. Some effects show up right away; others may not show up for many years.
- 5.2j Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals.

Dietary rice bran decreases plasma and whole-blood taurine in cats

ABSTRACT ←

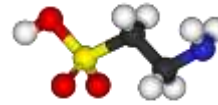
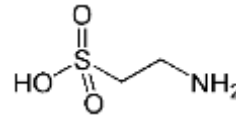
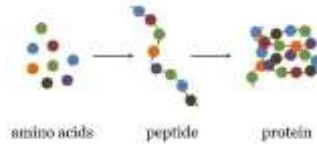
Taurine is an amino acid that cats must acquire (get) through their diet (food).

The **Abstract** is a brief summary of the article to come, often containing:

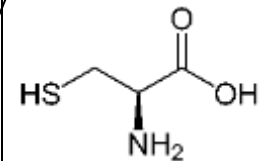
- Purpose / rationale of study (*why was this study done*)
- methodology (*how was this study done*)
- results (*what was found – in brief*)
- conclusion (*what do the findings mean and why does it matter – in brief*) [3]

Taurine:

- an amino acid, a chemical required building block of protein
- supports neurological development and cardiovascular health
- helps regulate water and minerals in blood (electrolyte balance), hearing function, immune modulation, insulin sensitivity
- large amounts found in the brain, retina of the eye, heart, and platelets (blood cells involved in clotting)
- sources: meat and fish (vegetarian and/or vegan diets may lack adequate amounts)
- found in many energy drinks (some studies suggest improves athletic performance)
- believed by some to be associated with longevity (long life span)
- available as human supplement
 - o used to treat congestive heart failure (CHF), high blood pressure, liver disease (hepatitis), high cholesterol (hypercholesterolemia), cystic fibrosis, seizure disorders (epilepsy), autism, attention deficit-hyperactive disorder (ADHD), retina disorders, diabetes, alcoholism
 - o used to improve mental performance and antioxidant (protect body cells from oxidation, chemical reactions involving oxygen) [5][6][7]



Cysteine – amino acid

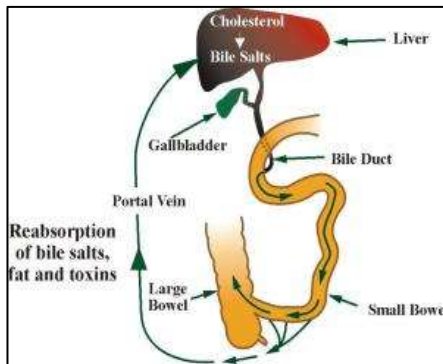


Synthesize – to make, combine, produce

Cats can **synthesize** a small amount of taurine from **cysteine**.

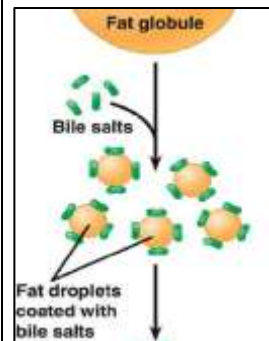
Metabolic Function – all processes (chemical reactions) involved in maintenance of living organism

However, this source of taurine is not enough to maintain important **metabolic functions**. Therefore, cats require taurine



from their diet. If inadequate (not enough) taurine is supplied by the diet, more taurine is lost in feces (poop) as **bile acids** than is synthesized (made).

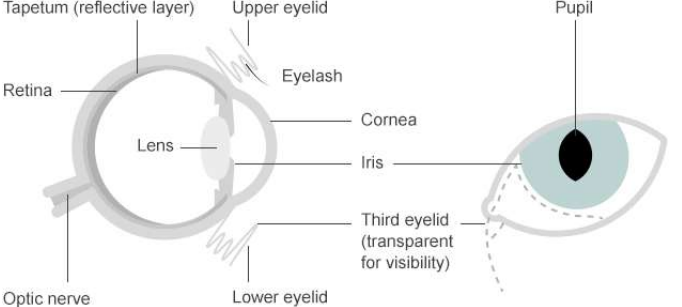
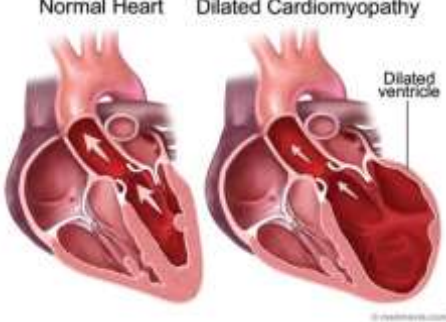
Bile Acids – found in bile (stored in gall bladder), made by liver for processing of cholesterol and fats in the intestine



A **deficiency** (not enough, lack of) of taurine results in **clinical diseases**, such as feline central retinal degeneration and dilated cardiomyopathy.

Clinical Diseases – a disease (abnormal condition, disorder) with recognizable clinical signs / symptoms

Retina – tissue lining back inner surface of eye, light sensitive, rods and cons (structure of retina) transmit images through nerves to the brain, resulting in vision

Feline Central Retinal Degeneration	cells of retina decline in function, resulting in impaired vision or blindness [4]	
Dilated Cardiomyopathy	left ventricle of heart (the main pumping chamber) is enlarged and weakened, doesn't relax and fill with blood properly, reduced blood pumping ability [1]	

Although most **commercial** feline (cat) diets have been supplemented with taurine to satisfy this requirement, taurine deficiency is still diagnosed in cats.

Commercial Cat Diets – in stores for public to purchase, merchandise, to make profit



WordPress. (2016, June 9). Hand the animals: The world of animal: Dog food brands list. Retrieved from <http://handheldpyrometer.com/dog-food-brands-list>.

Cats on canned food diets need more taurine than cats on dry (kibble) diets in order to prevent taurine deficiency.

- Taurine in canned cat food has less **bioavailability** due to processing.
- The fiber and fat content of canned cat food affects taurine metabolism by altering intestinal bacteria and changing the **excretion** of bile acids.
- Cats fed canned food diets (heat-processed or heat-treated purified) have lower concentrations of **plasma** and **whole-blood** taurine and excrete higher concentrations of total and secondary bile acids compared to cats fed dry diets (containing less soluble fiber, fat, and 1/3 less taurine).



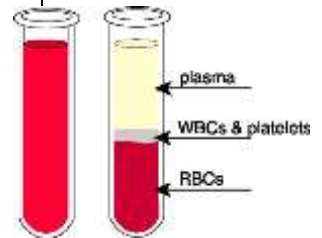
VS

Bioavailability – proportion that can be used by organism in the way needed

Excretion – process of eliminating or expelling waster matter

Plasma – liquid component of blood that holds blood cells

Whole Blood – blood draw directly from the body, no components (plasma or platelets) removed



Freeman, James. (2015, June 12). What is the different between blood plasma and blood cells? *Quora*. Retrieved from <https://www.quora.com/What-is-the-difference-between-blood-plasma-and-blood-cells>

- Cause...
 1. difference in intestinal microflora
 - a.k.a. gut flora – diverse community/ecosystem of microorganisms, including bacteria, living in the digestive tract
 - important for health, digestion/metabolism, absorption of nutrients, synthesis of vitamins B and K [2]
 2. fat levels in diet
 - Reversed by addition of **antibiotics** to the diet (within 3 weeks)
 - How...
 - decrease in fecal cholytaurine hydrolase activity (enzyme produced by intestinal bacteria)
 - decrease in total fecal bile acid excretion



Whiteman, Honor. (2015, March 11). The gut microbiome: How does it affect our health? *MNT*. Retrieved from <http://www.medicalnewstoday.com/articles/290747.php>.

Antibiotic – a group of medications used to treat infections caused by microbes such as bacteria and parasites

Conjugated – combined at molecular level (through bonds, sharing of electrons)

○ Cats **conjugate** bile acids exclusively with taurine. Therefore, any dietary factors that increase excretion of fecal bile acids will increase dietary requirement for taurine.

ARGUMENT

Taurine → Bile Acids, therefore...
↑ Bile Acid Excreted (made & expelled) = ↓ Taurine (Taurine used up), which causes...
↑ Taurine Requirement

INTRODUCTION ←

The **Introduction** is... the background, what is known about the topic, what is not known about the topic, previous work, current understanding of topic examined / studied, question want answered [3]

- Rice bran and whole rice products
 - Sources of moderately soluble fiber
 - Contain relatively high amounts of fat
 - Fiber, fat, and/or protein content of rice bran may increase excretion of bile acids, causing development of taurine deficiency



Taurine deficiency has been documented in a group of 15 Newfoundland dogs fed commercial lambmeal and rice diet.

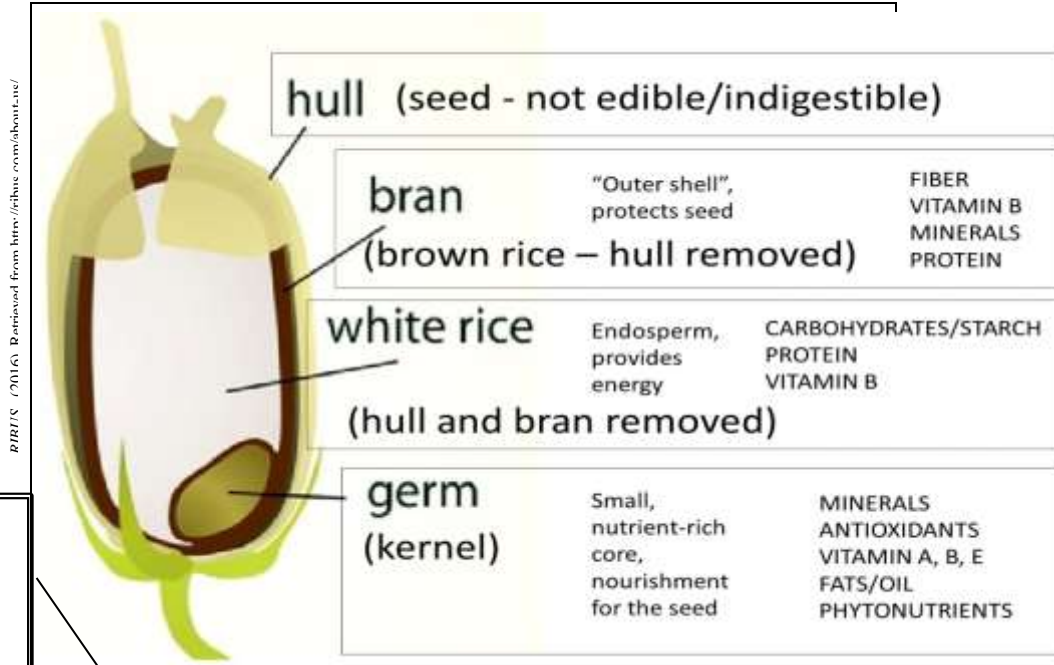
Lamb Meal – all lamb tissues (except blood, hair, hoof, horn, hide trimmings, manure, stomach, and rumen contents), cooked (rendered)

Dry Matter (DM) - mass when completely dry, remains after water evaporation

Rats fed a diet of rice bran at a 10% concentration (DM) had greater excretion of fecal bile acids than those fed a diet of 10% supplemented wheat bran (DM). Rice products are a common ingredient in commercial pet foods. Yet, no studies thus far have reported the impact of full-fat rice bran on taurine in cats. Cats fed rice bran diets may experience a similar loss of taurine through increased excretion of fecal bile acids, increasing their dietary requirement for taurine. This study sought to determine the effect of a purified diet (26% full-fat rice bran (DM)) on whole blood and plasma taurine concentrations in young adult cats.

Hypothesis – proposed explanation to be tested

Objective



The **Materials and Methods** section answers the question: How was the experiment done? [3]

MATERIALS AND METHODS

Cats of mixed ancestry (not purebred or belonging to a specific and recognized breed) are indicated by coat length, either domestic short-hair (DSH), the less commonly referred domestic medium-hair (DMH), or domestic long-hair (DLH)

sample size

- Sample:
 - o 16 male, intact (not neutered), domestic short-hair (DSH) cats 20-22 weeks old
- Environment:
 - o Housed in metabolic cages (60 x 60 x 60 cm) in rooms with controlled temperature (21 ± 2°C) and 14-h light/10-h dark cycle
- Diet:
 - o Access to food and water throughout the day
 - o Adaptation-Diet Feeding Period:
 - Prior to experimental diet implementation (before study began), all cats were adapted to a casein-lactalbumin-soy protein-based purified diet containing 1.5 g/kg taurine concentration (DM) for 2 weeks
 - o Experimental diets (diets tested/studied in this experiment):

Condition all cats with the same beginning (background/history), reduce impact of any prior diet on study results

Conditioned diet NRC-recommended levels of ingredients

Feline Nutrition and Pet Care Center, University of California, Davis - proven to support maintenance requirements via feeding trials



- **Baseline Diet:**
 - casein/lactalbumin-based purified diet ingredients (g/kg diet):
 - casein 180
 - lactalbumin 180
 - chicken fat 310.5
 - taurine 0.5 (shown to support maintenance in cats)
 - choline chloride 3
 - vitamin mixture 10
 - L-methionine 3
 - L-arginine 3
 - mineral mixture 50
- Each cat randomly assigned to one of the two groups:
 - Experimental Diet Group: 260 g/kg (26%) full-fat stabilized rice bran (12.1% DM acid detergent fiber and 31.3% DM neutral detergent fiber) added to baseline diet
 - Control Diet Group: 260 g/kg (26%) corn starch added to baseline diet
 - Cats remained on assigned diet throughout the study
 - Diets stored at 4°C between preparation and feeding (to prevent spoiling)
- **Data:**
 - Individual cat food intake (amount eaten) collected
 - Each cat weighed weekly
 - Cardiac auscultation and retinal (heart and eye) examination done before study began and after study completed
 - Blood samples
 - Collected at end of adaptation-diet feeding period (time 0 sample) and once during weeks 1, 2, 4, 6, 8, 12, 16, 22, and 40

Experimental Group – exposed to experimental conditions / procedure, independent variable tested upon, changes observed / recorded

Control Group – independent variable does NOT influence, used to rule out the influence of other factors / variables on the experimental results

Providing enough taurine to support maintenance in cats will reveal if rice bran in the diet impacts taurine in cats

Randomization used in experiments to reduce impact of bias/human choice on results

Centrifuge – machine that rapidly rotates to apply centrifugal force that separates contents

Heparin – anticoagulant (blood thinner), prevents blood from clotting

- Collected into heparinized syringes and separated into two tubes (whole blood and plasma)
 - Plasma isolation from whole blood:
 - centrifuge heparinized blood sample at 10,000 x g for 15 min
 - deproteinize (remove protein) with equal volume 0.24 mol/L sulfosalicylic acid
 - centrifuge 10,000 x g for 15 min at 4°C



Mckever, Kevin. (1) A centrifuge spins vials of liquid in a laboratory test. Shutterstock, clip art 625078. Retrieved from http://www.shutterstock.com/video/clip-625078-stock-footage-a-centrifuge-spins-vials-of-liquid-in-a-laboratory-test.html?src=rel/15149341_2_gg.

- All samples stored at -70°C until analysis
- Erythrocytes (red blood cells) lysed (membrane broken down) after 2 freeze-thaw cycles
- Diluted 1:1 with deionized water
- Deproteinization with equal volume 0.24 mol/L sulfosalicylic acid
- Taurine content analyzed using amino acid analyzer

The **Results** section presents what was found (data, calculations, graphs, tables) [3]

RESULTS

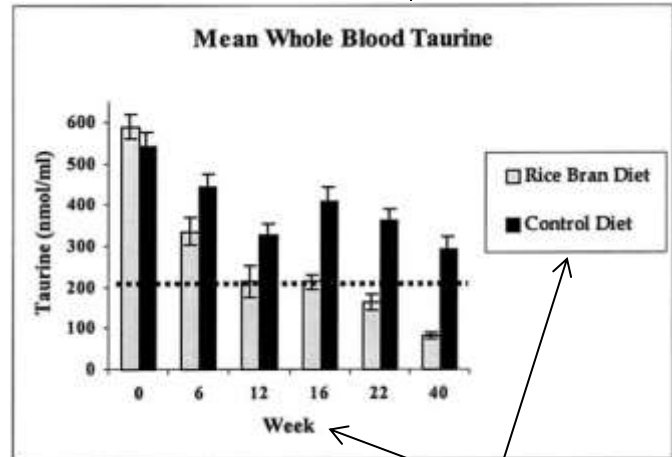
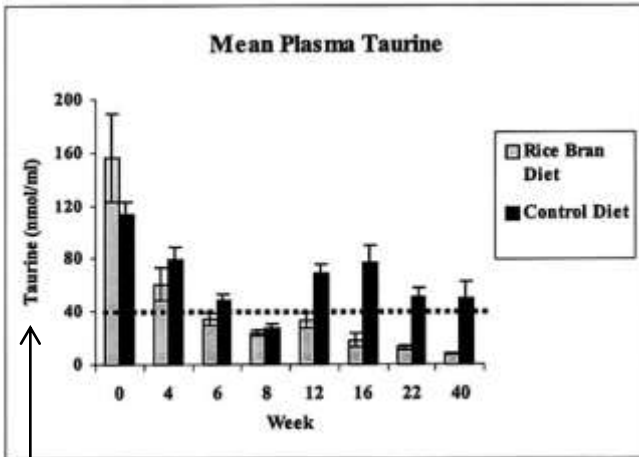
- At the start of the study, there were no differences in **mean** plasma or whole-blood taurine concentrations between the two groups.
- At 12 weeks, mean plasma taurine concentration was lower in the experimental group than the control group, and continued to decline thereafter (with experimental group mean plasma taurine concentrations consistently lower than control group)
- At 6 weeks, mean whole-blood taurine concentration was lower in the experimental group than the control group, and continued to decline thereafter (with experimental group

Mean – average, sum of all values in list divided by the number of items in list

$$\bar{X} = \frac{\sum X}{N}$$

Used to reduce impact of slight discrepancies bound to exist when dealing with living organisms

- mean whole-blood taurine concentrations consistently lower than control group)
- Critically low levels of plasma and whole-blood taurine were found in the experimental group at weeks 6 and 22



Dependent Variable – often represented with ‘y’ and on the y-axis of a graph, dependent on another variable (or the independent variable), the observed, the effect

The line above each bar indicates possible error margins and are common among scientific diagrams in order to be completely honest and representative.

DISCUSSION

The **Discussion** section covers the... conclusion, significance, meaning, context in broader scope, answer to posed question (hypothesis supported or not supported) [3]

Young-adult, intact, male cats that were fed a purified diet containing 26% full-fat stabilized rice bran (DM) had lower plasma and whole-blood taurine concentrations than those fed a purified diet containing 26% corn starch (DM) instead.

Cats require taurine from the diet (dietary requirement) due to limited activity of cysteine dioxygenase and cysteinesulfinate decarboxylase (the enzymes needed to convert cysteine to taurine, the only way a cat can make its own taurine). In addition, cats conjugate bile acids only with taurine, even when taurine is deficient. The only taurine degradation that occurs in cats is due to intestinal bacteria.

Independent Variable – often represented with ‘x’ and on the x-axis of a graph, what the scientist changes, the cause

The decline in taurine observed with the addition of rice bran to the cat diet is due to either...

- An increase in intestinal bacteria population due to the rice bran, which causes an increase in taurine degradation and a decrease in taurine concentration in plasma and whole-blood
- An increase in the excretion of fecal bile acids, which causes an increase in the loss of taurine through feces

Further research is needed to determine specific quantitative relationships between rice bran and taurine in cats.

It is common for further research suggestions to be presented toward the end of the article. No one study answers all possible questions on a topic completely. Further investigation, examination, and study is always needed.

Since enough taurine was supplied in both group diets to support maintenance in cats (based on previous study), the observed decline in taurine concentrations of plasma and whole-blood in the experimental group can be attributed to the presence of rice bran. Therefore, rice bran in diets lowers taurine levels in cat plasma and whole-blood. Cat diets containing rice bran should also contain higher concentrations of taurine than that deemed necessary to support maintenance (than in similar products without rice bran).

argument

recommendations based upon study results

GUARANTEED ANALYSIS:		INGREDIENTS: Ground yellow	
Crude Protein (Min)	32.0%	corn, soybean meal, corn gluten meal, meat and bone meal, beef tallow preserved with mixed-tocopherols (form of Vitamin E), turkey by-product meal, fish meal, animal liver flavour, phosphoric acid, salt, choline chloride, added colour, taurine, potassium chloride, DL-Methionine, zinc sulphate, Red 40, ferrous sulphate, manganese sulphate, niacin, Vitamin E supplement, Yellow 5, Blue 2, Vitamin A supplement, calcium pantothenate, copper sulphate, thiamine mononitrate, Vitamin B-12 supplement, riboflavin supplement, pyridoxine hydrochloride, Vitamin D-3 supplement, folic acid, calcium iodate, menadione sodium bisulfite complex (source of Vitamin K activity), sodium selenite, biotin. V-4520-C	
Crude Fat (Min)	9.0%		
Crude Fibre (Max)	4.0%		
Moisture (Max)	12.0%		
Calcium (Ca) (Min)	1.0%		
Phosphorus (P) (Min)	0.9%		
Taurine (Min)	0.12%		

Walmart. (2016). Purina Friskies Savoury Selections – Four Flavours Cat Food. Retrieved from <http://www.walmart.ca/en/ip/purina-friskies-savoury-selections-four-flavours-cat-food-3kg/6000071700395>

TAURINE

For cats, taurine is an essential amino acid.

EYES

Deficiency can lead to blindness.

BRAIN & NERVES

Taurine plays many roles in nerve and cell function. Taurine crosses the blood-brain barrier.

HEART

Deficiency can cause cardiomyopathy and death.

DIGESTION

Combines with bile acids for proper digestion.

IMMUNE FUNCTION

Taurine affects immune system responsiveness.

FETAL DEVELOPMENT

Deficiency can cause stillbirths, low birth weights and birth defects in kittens.



Taurine is found almost exclusively in meat and seafood.

The harder a muscle works, the more taurine it contains.



Taurine is water soluble. Don't discard the liquid from thawed raw foods!



It takes many months or years for symptoms of a deficiency to show up.

It's a good idea to add extra taurine to your cat's raw meat diet.



For more info, visit FelineNutritionFoundation.org

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- [1] *American Health Association*. (2016, July 8). Dilated cardiomyopathy (DCM). Retrieved from http://www.heart.org/HEARTORG/Conditions/More/Cardiomyopathy/Dilated-Cardiomyopathy_UCM_444187_Article.jsp#.
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Adapted Primary Literature (APL): Sample 3 – Climate Change and Invasive Plant Species

Lauren Thresh
The College at Brockport

Original Primary Literature (PL) Source:

Thakur, M. P., Reich, P. B., Eddy, W. C., Stefanski, A., Rich, R., Hobbie, S. E., & Eisenhauer, N.

(2014). Some plants like it warmer: Increased growth of three selected invasive plant species in soils with a history of experimental warming. *Pedobiologia*, 57, 57-60.

<http://dx.doi.org/10.1016/j.pedobi.2013.12.002>

NYS Standards:

The Living Environment Core Curriculum, The University of the State of New York, The State Education Department, <http://www.nysed.gov>

Standard 4:

Key Idea 1 - Living things are both similar to and different from each other and from nonliving things.

Key Idea 5 - Organisms maintain a dynamic equilibrium that sustains life.

Key Idea 6 - Plants and animals depend on each other and their physical environment.

Key Idea 7 - Human decisions and activities have had a profound impact on the physical and living environment.

Warmer soil increases growth of invasive plant species



Soil Microbiology is the study of organisms in soil.

1 gram of soil in and around plant roots (region called **rhizosphere**) can contain up to 10 billion bacterial cells. [1][4]

ABSTRACT

The Abstract is a brief summary of the article to come, often containing:

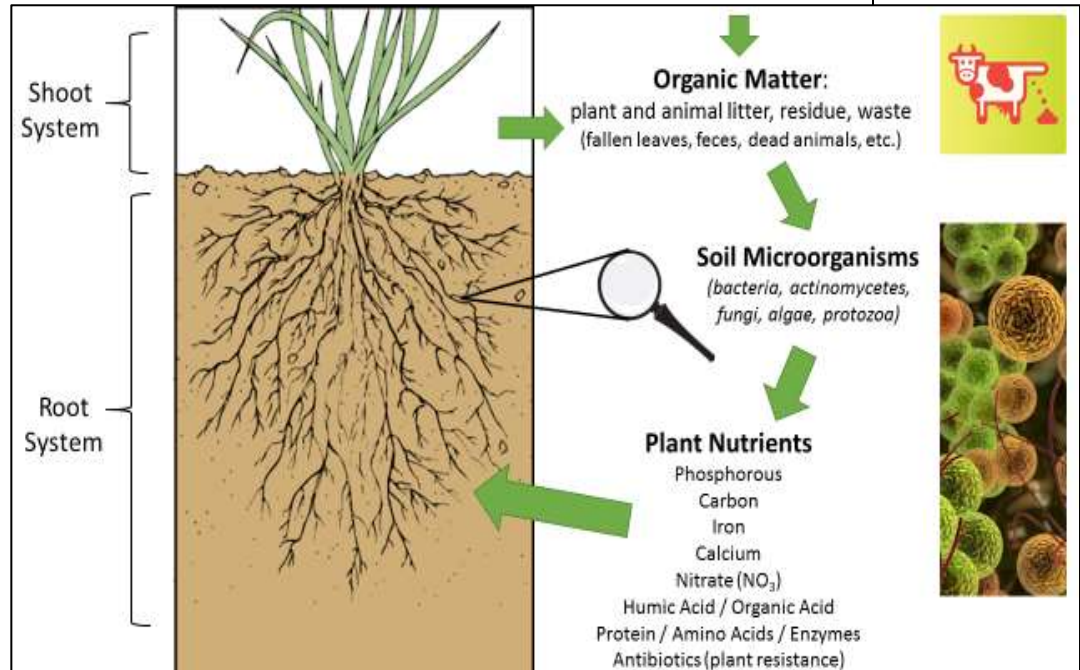
- purpose/rationale of study (*why was this study done*)
- methodology (*how was this study done*)
- results (*what was found – in brief*)
- conclusion (*what do the findings mean and why does it matter – in brief*) [3]

Increased soil temperature (soil warming) increases **microbial activity** within the soil. Plant nutrients in the soil are produced by microbial activity. Therefore, increased microbial activity increases plant nutrient production. This increase in available nutrients increases plant performance (growth, production of fruit and/or seeds, health, etc.).

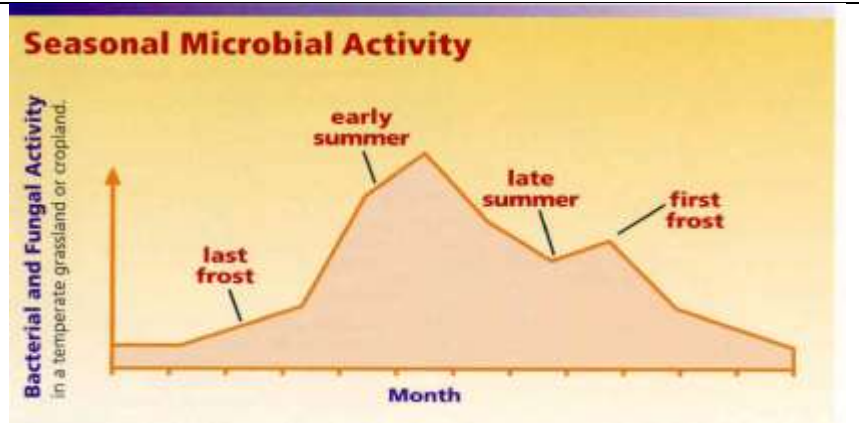
↑ soil temperature → ↑ soil microbial activity → ↑ plant nutrients available in soil → ↑ plant performance

Microbial Activity:

- processes performed by soil microorganisms
- indicator of soil quality
- plants depend on products of soil microbial activity for growth and development
- decomposition of organic matter
- production of carbon and nitrogen (carbon and nitrogen cycles) [1][4]



Ingham, Elaine R. (2016). Soil biology: Chapter 1: The soil food web. University of Illinois Board of Trustees. Retrieved from https://extension.illinois.edu/soil/soilBiology/soil_food_web.htm.






higher temperature increases rate of enzyme activity (even in soil microorganisms) → which increases rate of microbial activity → increasing plant nutrients produced by soil microbes

Invasive species – a plant, animal, or pathogen species not native (alien) to an ecosystem in which it has been found living and is likely to cause harm to that ecosystem (if it hasn't already done so)

This study tested three **invasive** plant species under three different warming histories over the course of four years to examine the effect of experimental soil warming on the growth of such species.

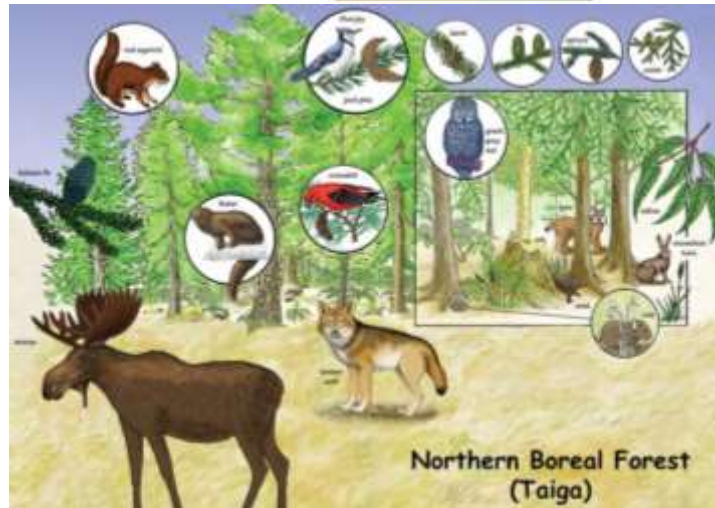
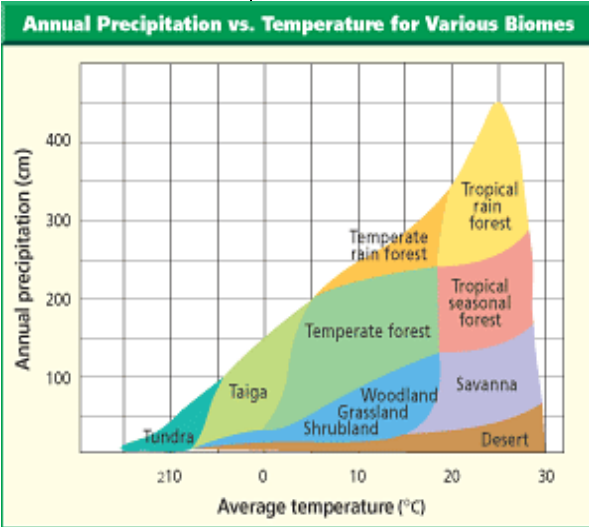
invasive to temperate-boreal ecotone of North America (study site)

INVASIVE PLANT SPECIES STUDIED		
<p><i>Trifolium pretense</i> (legume) a.k.a. the red clover</p> 	<p><i>Phleum pretense</i> (grass) a.k.a. Timothy</p> 	<p><i>Plantago lanceolata</i> (herb) Flowering plant in plantain family</p> 
<p>LOCATION: temperate-boreal forest ecotone of Minnesota (USA)</p>		
<p>ecotone – area of transition between two biomes, where two communities meet and mix, examples: between a field and forest, between a forest ecosystem and grassland ecosystem</p> <p>biome – community of plants and animals, occupy a distinct region, usually defined by climate and dominant vegetation, examples: grassland, tundra, desert, tropical rainforest, deciduous forests, coniferous forest</p> <p>boreal forest – northern hemisphere, a.k.a. Taiga, cold, heavy snow fall, average annual temperatures 5°C to -5°C, coniferous forests (pines, spruces, larches)</p> <p>temperate forest – northern and southern hemispheres (temperate regions), further categorized by climate and geography that results in dominating tree species, can be a mixture of the following:</p> <ul style="list-style-type: none"> • temperate coniferous forests (evergreen) • temperate rainforest (heavy rainfall and dense humidity) • temperate deciduous forests (broadleaved, leaf-shedding: maple, elm, oaks) 		
<p>This study was conducted at the transition between a boreal forest and a temperate deciduous forest.</p>		<p>[5][7]</p>
WARMING HISTORIES (OVER 4 YEARS)		
ambient	ambient + 1.7°C	ambient + 3.4°C

ambient – temperature of surrounding area / environment (temperature-boreal forest of Minnesota, USA)

Nelson, Rob. (2003). Taiga – Boreal forest. The Wild Classroom & Exploring Biodiversity: Biomes of the World. Retrieved from <http://www.thewildclassroom.com/biomes/taiga.html>.

Boreal / Taiga Forest:



McGraw-Hill Global Education Holdings, LLC.: Glencoe OLC. (2016). Science: Biology: The dynamics of life, Indiana edition: Chapter 3: Communities and biomes. Retrieved from http://glencoe.mheducation.com/sites/0078675626/student_view0/unit2/chapter3/chapter_test.html.

Temperature rises will have many implications, soil warming is just one. Soil warming will effect plants in many ways, increasing microbial activity is just one. This study is examining one path with which increasing temperature will alter the current state of the planet. Studies examine one condition at a time.

Amsel, Sheri. (2016). Northern boreal forest (taiga) with species named. Exploring Nature Educational Resource: Life Science, Earth Science, and Physical Science Resource for K-12. Retrieved from <https://www.exploringnature.org/db/view/4557>.

The Introduction is... the background, what is known about the topic, what is not known about the topic, previous work, current understanding of topic examined / studied, question want answered [3]

INTRODUCTION

Temperature is predicted to rise for the 21st century, warming soil temperature. Higher soil temperatures will increase soil microbial activity. Since soil microbial activity produces plant nutrients, an increase in such activity will increase the production of plants nutrients. This change in soil composition (increase in plant nutrients available for uptake) will impact the growth and survivability of plant species.



Plant Functional Type (PFT) / Group – plant species are grouped according to their function (purpose, role) in an

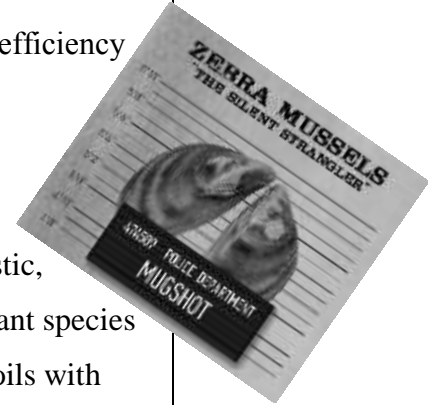
Plant functional groups and even plant species within a community have different genetic **traits** (DNA) that produce a

Traits – a characteristic determined by genes/DNA (inherited) or environment

ecosystem and their use of resources, used by modelers to simplify the great diversity of plants in order to analyze how vegetation is likely to respond to climate change

variety of photosynthetic rates (rate of photosynthesis) and nutrient uptake rates (rate in which plant takes / uses nutrients from soil). Therefore, changes in soil temperature will effect plant species differently. Greater nutrient availability does not mean that all plants will experience the same increase in nutrient uptake and, therefore, the same increase in benefit (growth, for example).

For example, it has been reported that legume species have a lower response than grass species to the presence of additional nutrients. In addition, legume species can benefit other plant species with which they coexist by nutrient transfer in the root zone. A plant species ability to benefit from the increase in nutrient availability will depend on the plant species' efficiency (success) at capturing the nutrients made available.



Invasive plant species are often considered opportunistic, exploiting nutrient availability. Therefore, invasive plant species are likely to benefit from soil warming. In addition, soils with extreme weather history have been shown to promote growth in invasive plant species more so than soils without such history.

Perhaps, invasive species will benefit more from soil warming than native plant species, growing and reproducing faster than native species. This would likely lead to invasive species outcompeting native species for space and other resources, reducing native plant species. Biodiversity of the ecosystem would decrease, likely harming other species, human activity, and the resilience of the ecosystem to survive future changes/threats.



This experiment was considered a microcosm.

Microcosm – “small world”, representation on small scale, miniature depiction of characteristics of something much larger

MATERIALS AND METHODS ←

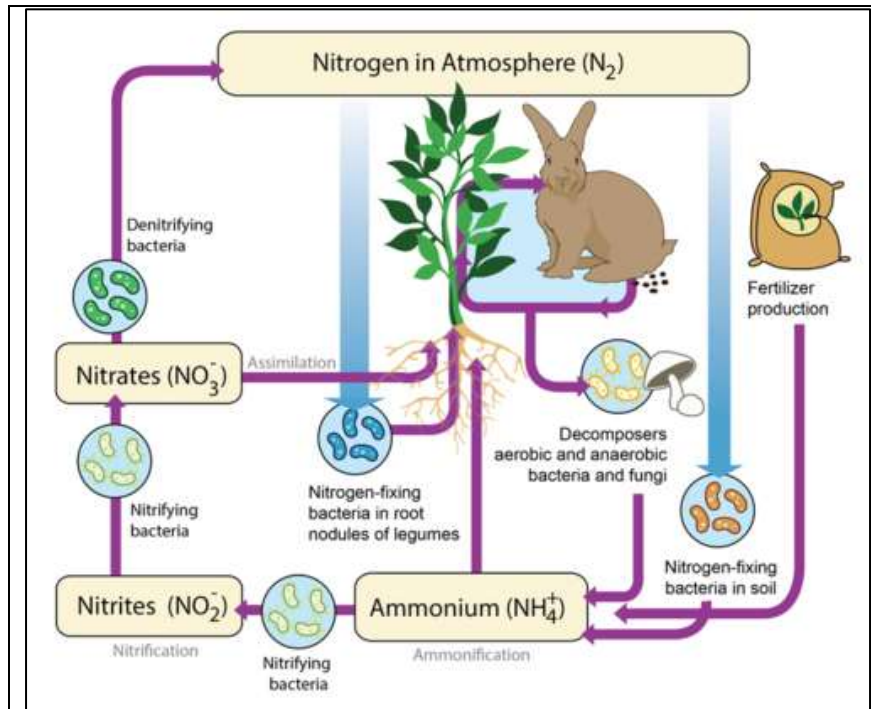
- Location: ecotone region between a temperate and boreal forest, Minnesota, USA
 - two sites located ~100km apart: Cloquet (Cloquet Forestry Center) and Ely (Hubachek Wilderness Research Center)
 - six random blocks at each site
 - three warming treatments within random blocks
 - surrounding vegetation consisted of 11 tree species (5 temperate, 5 boreal, and 1 invasive)
- Experimental Warming: infrared heaters and resistance heating cables artificially simulated warming both above and below ground
 - three warming treatments
 - ambient
 - ambient +1.7°C
 - ambient +3.4°C
- Time: experiment run since 2008
- Plant Preparation: 5 seeds of each invasive species per **microcosm** (15 seeds total per microcosm)
 - three invasive plant species tested
 - legume – *Trifolium pretense*
 - grass – *Phleum pretense*
 - herb – *Plantago lanceolata*
- Data Collection:
 - soil N (nitrogen) concentration
 - soil collected (2.5cm diameter, 10cm depth) from each plot
 - N concentration measured by combustion-gas chromatography using a CHNO-analyzer

The **Materials and Methods** section answers the question:

How was the experiment done? [3]

← model / representational plant species

} Latin name of species: *italicized, only FIRST letter of first name capitalized*



Cerezo, John. (2016). Exploring the nitrogen cycle. *BetterLesson*. Retrieved from <http://betterlesson.com/lesson/640166/exploring-the-nitrogen-cycle>.

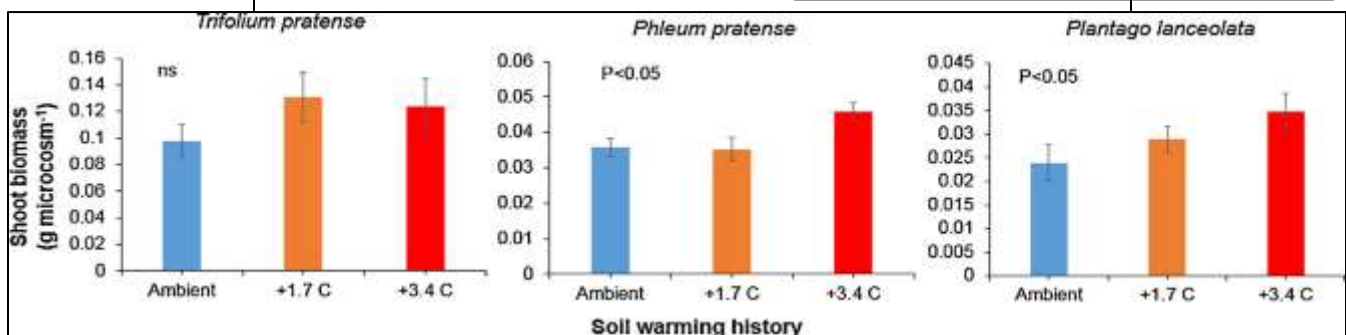
- plant growth
 - plants harvest 34th day from start
 - plants dried 48 h at 70°C before measurements of shoots and roots taken

Biomass – total mass of organism in given area or volume

- shoot biomass measured
- root total biomass estimated (roots of individual plants couldn't be separated)

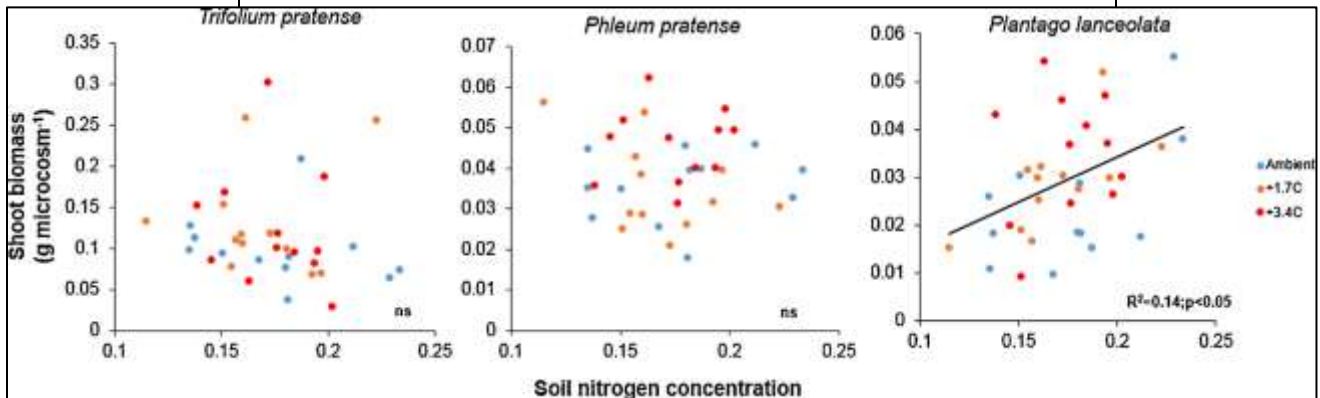
RESULTS ←

The **Results** section presents what was found (data, calculations, graphs, tables) [3]



The thin brackets toward the top of each bar represent standard error. They account for the possible influence of error in the results (such as human error).

line of best fit – line that best represents data of a scatter plot



Dependent Variable – often represented with ‘y’ and on the y-axis of a graph, dependent on another variable (or the independent variable), the observed, the effect

Independent Variable – often represented with ‘x’ and on the x-axis of a graph, what the scientist changes, the cause

- Soil warming histories affect plant growth.
- Shoot biomass of *Phleum pratense* and *Plantago lanceolata* increased under soil warming conditions. Compared to ambient soil, ambient +3.4°C resulted in an increase in shoot biomass of 45% for *Phleum pratense* and 28% for *Plantago lanceolata*.
- No significant change in shoot biomass was found for *Trifolium pratense*.
- Total root biomass increased significantly in soils with a warming history. Compared to ambient soil, root biomass increased 26% for ambient +1.7°C soil and 47% for ambient +3.4°C.
- Soil microbial biomass (the quantity of soil microbes) was **positively correlated** with total shoot biomass. But, the variation of soil microbial biomass (types of microbes) was not shown to be influenced by the soil warming treatments.
- The different soil warming treatments did not produce a difference in soil N concentration.
- Soil N concentration was positively correlated with shoot biomass of only *Plantago lanceolata*.

Positive Correlation - the same direction, both increase or both decrease

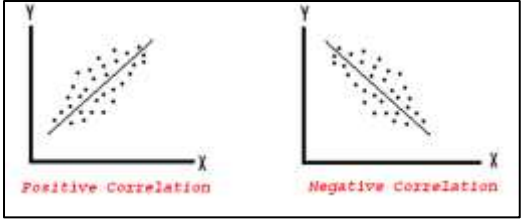
Suggests variability in plant species traits associated with utilizing soil nitrogen.

Possibly indicating a competitive disadvantage in exploiting soil nitrogen.

– A **negative correlation** was observed between the shoot biomass of *Trifolium pretense* and soil N concentration.

Negative Correlation – opposite direction, one increases and the other decreases (or vice versa)

The **Discussion** section covers the... conclusion, significance, meaning, context in broader scope, answer to posed question (hypothesis supported or not supported) [3]



DISCUSSION

Although plant biomass increased in soils with a warming history (first hypothesis confirmed), only marginal differences were found among the three plant species under the three warming treatments (second hypothesis partially supported).

The results of this experiment showed a weak relationship between soil warming and microbial biomass, in addition to soil warming and total soil N concentration. Other components of soil that impact nutrient uptake, like plant pathogens and **mutualistic relationships** among plant species, may be impacted by soil warming. Therefore, further research is needed to determine the reason soil warming increases shoot and root growth.

Mutualistic Relationship – both benefit, work together

Types of Symbiosis (interactions) [6]



Interaction	Species A	Species B
<u>Commensalism</u>	Receives benefit	Not affected
<u>Mutualism</u>	Receives benefit	Receives benefit
<u>Parasitism</u>	Receives benefit	Harmed

In addition, further research is encouraged to assess...

- (1) response differences of plant species to soil warming (particularly differences between native and invasive plant species)
- (2) the implications of soil warming on plant communities (and, therefore, ecosystems as a whole)

* *Further research recommendations often appear at the end of science journal articles because learning is never done.*

- (3) the impact of soil warming on microbial populations and their activity
- (4) the effect of soil warming on soil nutrient composition

References

- [1] *Bioscience: Integrating Resource Management*. (2014). Soil microbial ecology. Retrieved from <http://www.biosciencewa.com/Agriculture/soilmicrobialecolology.html>.
- [2] *Conservation Institute*. (2016, August 17). Top 100 invasive species. Retrieved from <http://www.conservationinstitute.org/the-top-100-invasive-species/>.
- [3] *Duke University: Medical Center Library & Archives*. (2016, July 7). Scientific writing: Sections of a paper. Retrieved from <http://guides.mclibrary.duke.edu/scientificwriting/sections>.
- [4] Fortuna, Ann-Marie. (2012). The soil biota. *The Nature Education: Knowledge Project*, 3(10), 1. Retrieved from <http://www.nature.com/scitable/knowledge/library/the-soil-biota-84078125>.
- [5] Gosz, James R. (1993, August). Ecotone Hierarchies. *Ecological Applications*, 3(3), 369-376. doi: 10.2307/1941905
- [6] Grabianowski, Ed. (2008, March 7). How symbiosis works. *HowStuffWorks: Science*. Retrieved from <http://science.howstuffworks.com/life/evolution/symbiosis1.htm>.
- [7] *University of California Museum of Paleontology*. The forest biome. Retrieved from <http://www.ucmp.berkeley.edu/exhibits/biomes/forests.php>.

Adapted Primary Literature (APL): Sample 4 – Biofilms and Antibiotic Resistant Bacteria

Lauren Thresh
The College at Brockport

Original Primary Literature (PL) Source:

Singhai, M., Malik, A., Shahid, M., Ashraf Malik, M., & Goyal, R. (2012). A study on device-related infections with special reference to biofilm production and antibiotic resistance. *Journal of Global Infectious Diseases*, 4(4), 193-198. doi: 10.4103/0974-777X.103896

NYS Standards:

The Living Environment Core Curriculum, The University of the State of New York, The State Education Department, <http://www.nysed.gov>

Standard 4:

- 1.3a The structures present in some single-celled organisms act in a manner similar to the tissues and systems found in multicellular organisms, thus enabling them to perform all of the life processes needed to maintain homeostasis.
- 3.1g Some characteristics give individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase.
- 5.2b Viruses, bacteria, fungi, and other parasites may infect plants and animals and interfere with normal life functions.
- 5.2j Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals.
- 6.1g Relationships between organisms may be negative, neutral, or positive. Some organisms may interact with one another in several ways. They may be in a producer/consumer, predator/prey, or parasite/host relationship; or one organism may cause disease in, scavenge, or decompose another.
- 7.3b The decisions of one generation both provide and limit the range of possibilities open to the next generation.

Biofilms and antibiotic resistant bacteria



ABSTRACT

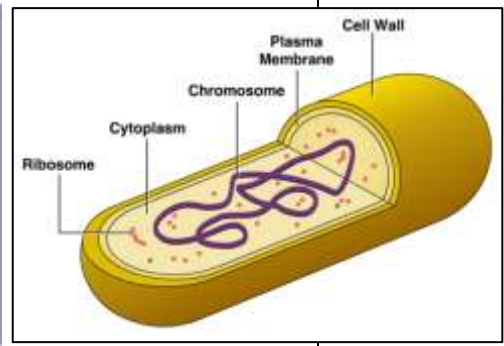
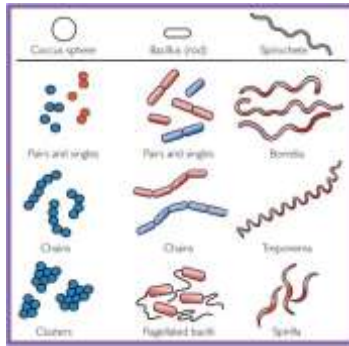
The Abstract is a brief summary of the article to come, often containing:

- purpose/rationale of study (*why was this study done*)
- methodology (*how was this study done*)
- results (*what was found – in brief*)
- conclusion (*what do the findings mean and why does it matter – in brief*) [7]

Indwelling medical devices (IMDs) are routinely used for hospital patients in **critical condition**. IMDs are susceptible (vulnerable) to the growth of **bacteria**. In particular, bacteria that product **biofilms**. Characteristics (features) of bacterial biofilms promote (increase the likelihood of) **antibiotic resistance**. This leads to **resistant device-related infections (DRI)**. DRIs pose new challenges to patient treatment.

Critical condition:

- severe, life-threatening
- unstable vital signs (status of body's life-sustaining functions: body temp., blood pressure, pulse / heart rate, respiratory / breathing rate)
- unpredictable prognosis (likely outcome, forecast, course)



Bacteria – single celled, no nucleus, no membrane bound organelles, DNA single loop, may have a plasmid

IMD – Indwelling Medical Device:

left within a bodily organ or passage to maintain drainage, prevent obstruction, or provide a route for administration of food or drugs (Merriam-Webster)

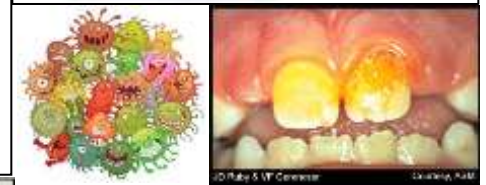
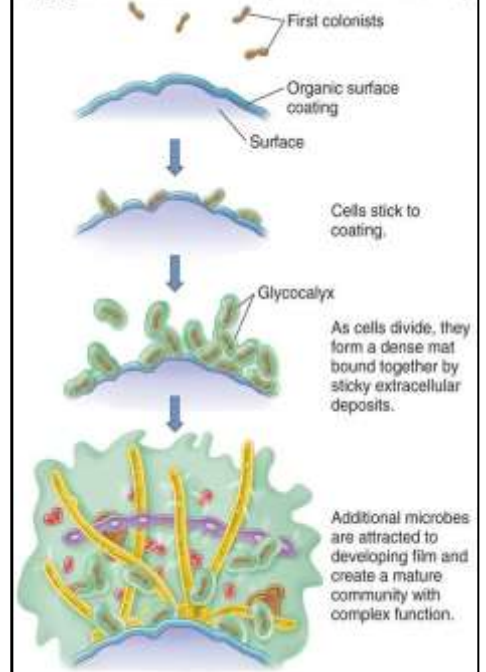
the three kinds examined in this study:

intravascular catheter	urinary catheter	endotracheal tube
<p><i>Citius Pharmaceuticals.</i> (2016). Catheter-related blood stream infections. Retrieved from https://www.citiuspharma.com/crbsi/.</p> <p><i>Drugs.com.</i> (2016). Caring for a peripherally inserted central catheter or midline catheter. Retrieved from https://www.drugs.com/cg/caring-for-a-peripherally-inserted-central-catheter-or-midline-catheter.html.</p>		<p><i>Medical Dictionary.</i> (2009). Endotracheal tube. Retrieved from http://medical-dictionary.thefreedictionary.com/endotracheal+tube.</p>

Biofilm:

Bacteria attaches to a surface by excreting a slimy, glue-like substance. This occurs in a moist (aqueous) environment with plenty of available nutrients the bacteria needs (nutrient-rich environment). These locations /surfaces can be both inert (nonliving) and living: such as rocks in streams, pipes and other metals, plastics, plants, and body tissues (such as the plaque on teeth). This initial / pioneer bacteria provide a different, more diverse surface for other species and substances to attach, even those that would not have been able to attach to the primary surface on their own. Other bacteria species, fungi, yeasts, protozoa, other microorganisms, and debris can continue to pile on. The components (species) of biofilms are held together and enclosed (covered) by stands of sugar molecules (extracellular polymeric substances, EPS). This allows a complex, three-dimensional (3D), and robust (resilient) *community* to form. Biofilms can grow to be many inches thick. Some species of bacteria are able to communicate with other species of bacteria using chemicals. Members of the biofilm community share resources and cooperate. For example, protection from the immune system or antibiotics. This allows different species of microorganism to benefit from the strengths of others, strengths they may not have themselves. In some cases, the waste or by-products of one species may be a necessary resource for another not found in that location (example oxygen). This allows microorganisms to thrive in places they otherwise would not. This makes biofilms very dangerous and difficult to eradicate (remove). [5][6][10]

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similar to why people live in communities

evolution of bacteria

the role of overuse of antibiotics

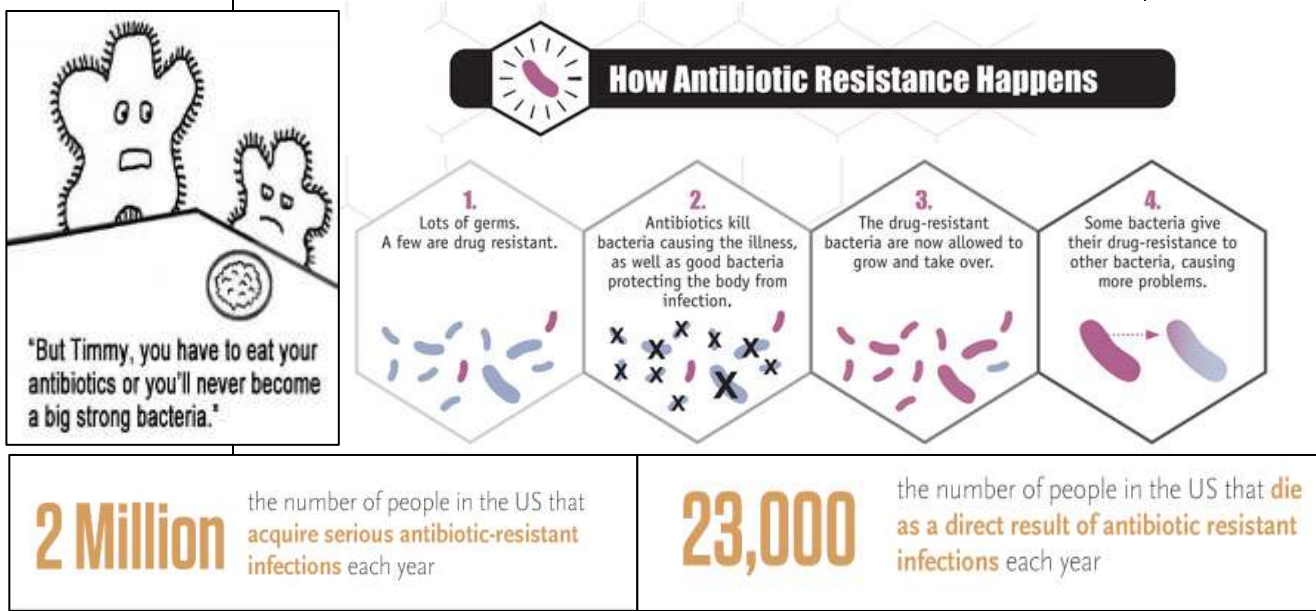


overuse of antibacterial soap and hand sanitizer



Antibiotic Resistance / Antibiotic Resistant Bacteria:

Antibiotics (antimicrobial drugs) either (1) kill bacteria or (2) make it difficult for the bacteria to grow and multiply. Since some antibiotics have been widely used for a long time (example: Penicillin), the bacterial species it is intended to kill adapts. Due to genetic variation, one or a number of bacterial cells were immune / resistant to the antibiotic. In other words, those cells were different enough that the antibiotic was less effective against them. These bacterial cells survived the antibiotic, continuing to multiply and spread. The majority of the bacterial population of that species is now the result of these early survivors, adapted / resistant to the antibiotic. In other words, antibiotic resistance is when an antibiotic no longer controls a species of bacteria's growth or kills a species of bacteria. The bacteria are resistant to the antibiotic and continue to multiply in the presence of the antibiotic. Antibiotic resistant illnesses are more expensive and more difficult to treat. The more an antibiotic is used, the more likely antibiotic resistance is to occur. [1][4]



sample size

In this study, 135 hospitalized **pediatric** patients (in **intensive care units**) with *different* IMDs were studied to determine the **rate of infection** associated with *each* device (the device-specific infection rate). The presence of biofilms, the identification of bacteria within the biofilm (bacteriological profile of biofilms), and the presence of antibiotic resistance was examined. It was found that DRIs are on the *rise*.

Pediatric – infant, children, adolescent, and young adult

Rate of Infection –disease progression (progress / success) within a set period of time

Intensive Care Unit (ICU) – patients in critical condition are intensively treated by specially trained staff, special department of hospital or health care facility

$$\frac{\text{Number of device-related infections} \times 100}{\text{Number of patients on device}}$$

Device Specific Infection rates = $\frac{\text{Number of device-related infections} \times 100}{\text{Number of patients on device}}$

The **Introduction** is... the background, what is known about the topic, what is not known about the topic, previous work, current understanding of topic examined / studied, question want answered [7]

INTRODUCTION

The extensive and routine use of indwelling medical devices (IMDs) as part of critical patient care in hospitals has increased the occurrence (incidence) of device-related infection (DRI). DRI is when an infection occurs at least 48 hours after a device began use in a patient. These devices are intravascular catheter, endotracheal tube, or indwelling urinary catheter. The devices render (make) a patient vulnerable to microbial colonization (growth of microorganisms), including biofilm producing bacteria (bacteria that

give rise to biofilms). Biofilms can then lead to bacteria resistant infections, which are very difficult (and more expensive) to treat.

IMDs → DRI → biofilm → antibiotic resistance → patient treatment challenges (or death) → global threats / consequences (cost, pandemics, epidemics, etc.)

The majority of DRIs, in order of prevalence, are...
 (1, greatest occurrence) catheter-related blood stream infections (DRBSI),
 (2) catheter associated urinary tract infections (CAUTI), and
 (3) ventilator associated pneumonia (VAP).

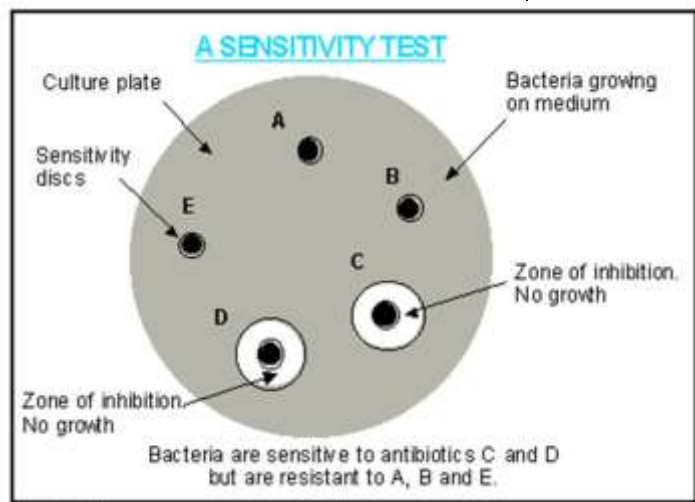
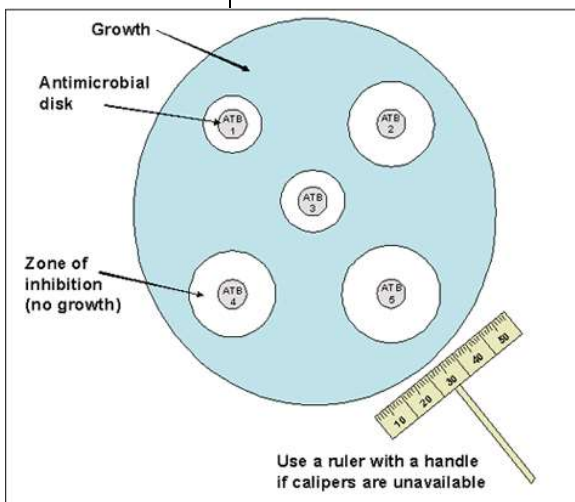
The **Materials and Methods** section answers the question:
 How was the experiment done? [7]

MATERIALS AND METHODS

- Sample: 135 hospitalized pediatric patients in intensive care units with IMDs
 - 105 intravascular catheters
 - 15 urinary catheters
 - 15 endotracheal tubes
- Infection prior to use of IMDs ruled out by complete blood count, chest x-rays, and urine culture
- If DRI suspected:
 - IMD removed
 - IMD tip cut with sterile blade (to eliminate contamination during cutting)
 - IMD tip sent to microbiology laboratory for testing in sterile container (to eliminate contamination during storage and transport)
 - If CRBSI suspected –
 - intravascular catheter tip culture done using role plate method
 - If CRBSI, CAUTI, or VAP suspected –
 - blood, urine, and bronchoalveolar lavage (BAL) analyzed

to ensure infection caused by IMDs (a true DRI) and not present prior to device use

- the susceptibility of bacteria to various antibiotics was determined using the Kirby-Bauer disk diffusion method
 - bacteria from the patient is isolated
 - a plate of Muller Hinton Agar (ideal growth media for the bacteria being tested) is prepared
 - the isolated bacteria is spread evenly onto the Muller Hinton Agar
 - disks / wafers, each containing a measured amount of one antibiotic, are placed on top of the bacteria spread agar
 - the bacteria is grows overnight under proper temperature, humidity, and lighting conditions
 - the area surrounding each wafer / disk that has no bacterial growth is measured (the zone of inhibition)
 - the greater the zone of inhibition, the more sensitive the bacteria is to the antibiotic present on the wafer / disk
 - if there is no zone of inhibition, the bacteria is not sensitive to the antibiotic present on the wafer / disk (resistant) [8]



The **Results** section presents what was found (data, calculations, graphs, tables) [7]

RESULTS

- Rates of biofilm DRI:
 - CRBSI – 10.4%
 - CAUTI – 26.6%
 - VAP – 20%

– *Klebsiella pneumoniae* was the most common bacterial biofilm causing DRI, at 61.1%

K. pneumoniae normally found in human intestine (doesn't cause harm), but can cause illness when gets to other areas of body

- spread by person-to-person contact (not airborne)
- typically a 'nosocomial' infection (get in hospital or healthcare setting)
- result of weakened immune system and medical treatment procedures (IMDs)
- taking antibiotics over long periods of time increases risk [3]

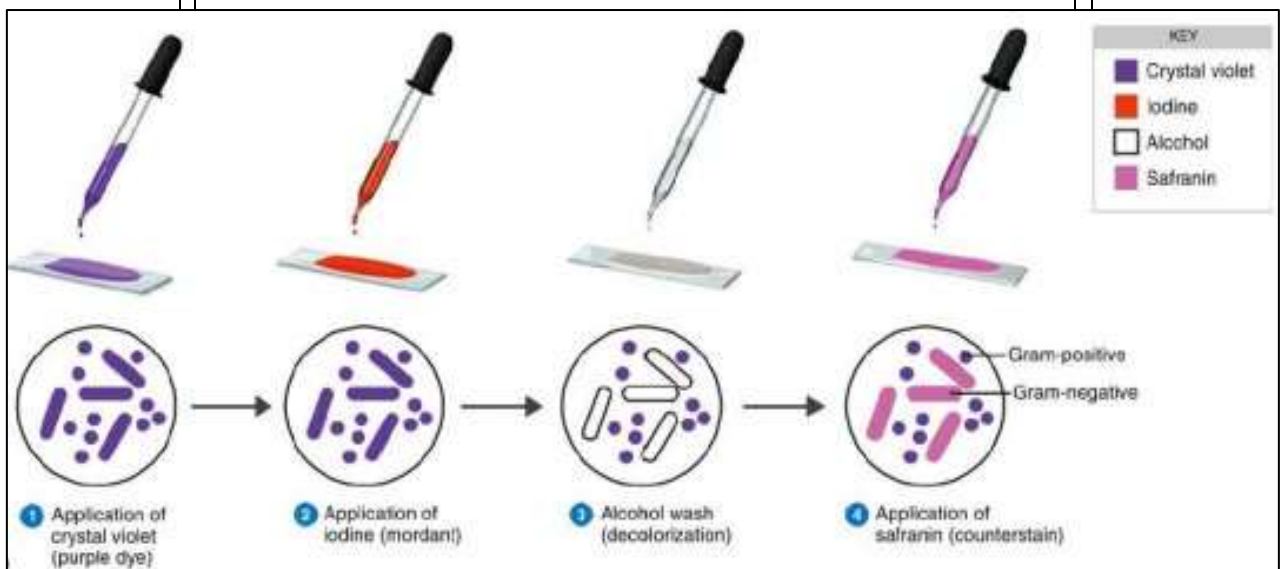


- Patients with DRI also had biofilms on their IMDs
- The bacteria that caused the DRI were found to have grade 3 (moderate) and grade 4 (strong) adherences
 - Meaning, the bacteria that caused the DRI had moderate-to-strong ability to produce biofilm
- Antimicrobial susceptibility testing:
 - 18 out of 21 bacteria that produced biofilms were multidrug resistant
 - 15 out of 16 gram-negative bacilli bacteria that produced biofilms were multidrug-resistant
 - 3 out of 5 Staphylococcal biofilms were multidrug-resistant

In 1884, Christian Gram (a Danish Physician) developed a staining technique to distinguish two types of bacteria. Gram staining reacts to differences in the cell walls (detects properties of peptidoglycan) of the two bacterial types.

Procedure:

1. Bacterial cells are fixed to a microscope slide (fixed so that they remain on the slide and do not come off during the following procedures)
2. Bacterial cells on slide are stained with crystal violet
3. Bacterial cells on slide are treated with iodine solution
4. Bacterial cells on slide are washed with alcohol (de-staining solution)
 - (+) Gram Positive bacteria retain purple color
 - (-) Gram Negative bacteria lose purple color
5. Bacterial cells on slide are stained with safranin or fuchsin
 - (-) Gram Negative bacteria turn red
 - (+) Gram Positive bacteria remain purple [2][9]

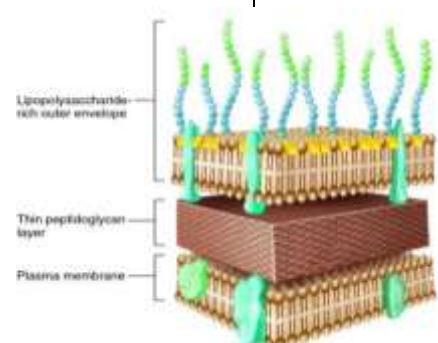
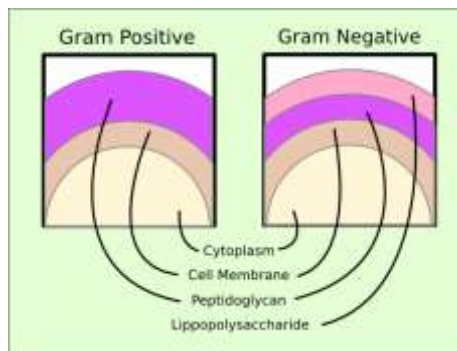
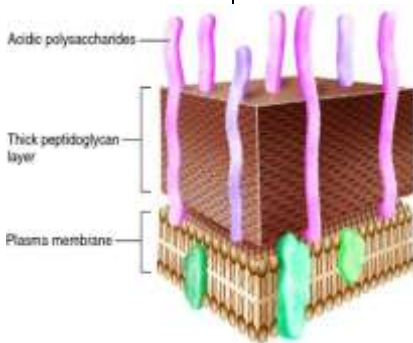




Gram Positive



[2][9]		
	Gram Positive	Gram Negative
Gram Stain Result	stain purple color and appear purple under microscope	stain red color and appear red under microscope
Cell Wall	Single layer Thick (15-20nm) Straight Even Rigid (due to high proportion of peptidoglycan 80%)	Two layered Thin (7.5-12nm) Uneven (wavy) Less rigid, more elastic (due to less peptidoglycan 2-12%)
Cell Features	Outer membrane absent Lipid content low (1-4%) Resistant to physical disruption	Outer membrane present Lipid content high (11-22%) Susceptible to physical disruption
Antibiotic Resistance	More susceptible to antibiotics	More resistant to antibiotics
Examples	Bacillus subtilis, Streptococcus, Lactobacillus, Leuconostoc, Clostridium	Escherichia coli, Rhizobium, Vibrio, Acetobacter



DISCUSSION / CONCLUSION

DRI infections are responsible for higher morbidity (death) and therapeutic failure, than the initial condition for which the patient admitted / treated alone. Given this and the results of this study, the researchers encourage regular hospital surveillance of DRI and antibiotic guidelines (to reduce antibiotic misuse that results in

recommendation in response to study results, common component of 'Discussion' section

The **Discussion** section covers the... conclusion, significance, meaning, context in broader scope, answer to posed question (hypothesis supported or not supported) [7]

antibiotic resistant bacteria). The researchers also recommend the continued study of such infection patterns across various settings (countries with differing medical practices).

It is common for further research suggestions to be presented toward the end of the article. No one study answers all possible questions on a topic completely. Further investigation, examination, and study is always needed.

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