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ОСНОВИ АНГЛОМОВНОЇ АКАДЕМІЧНОЇ КОМУНІКАЦІЇ ДЛЯ СТУДЕНТІВ ТА АСПІРАНТІВ ПРИРОДНИЧИХ СПЕЦІАЛЬНОСТЕЙ

Навчальний посібник

Львів
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BASICS
OF ENGLISH ACADEMIC COMMUNICATION FOR SCIENCE MAJORS

Coursebook

Lviv
2015

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Навчальний посібник укладено відповідно до вимог щодо навчально-методичного забезпечення викладання дисциплін «іноземна мова» та «іноземна мова професійного спрямування» у вищій школі.

Посібник призначено для розвитку теоретичних і практичних знань студентів старших курсів, магістрантів, аспірантів та наукових працівників природничої галузі. Зосереджено увагу на особливостях англомовної науково-академічної комунікації, лінгвістичній природі та стратегії дискурсу природничих наук, формуванні навичок та умінь активного читання, академічного письма й усного мовлення у природничій сфері, розширення словникового запасу загальнонаукової та професійної лексики.

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CONTENTS

INTRODUCTION

Humans are social beings. They interact with each other through communication. Ability to communicate effectively is fundamental to a successful life in our society and it is of great importance for all areas of life. Communicative competence is needed not only in social interaction at the interpersonal level, but also at organizational and public levels, as well as for intercultural and professional exchanges. As we participate in such interactions within various social groups, we join different discourse communities, for example professional, scientific, cultural or academic.

Academic communication refers to various forms of spoken and written discourse taking place in the context of higher education. The written forms might be exemplified by conference proposals, research papers, lab reports, academic essays, etc. The spoken academic discourse can be represented by group discussion or project work, conference presentation or student-teacher classroom interaction.

As you progress with your university education, you socialize in the academic discourse community which means you develop your voice, identity and agency in it with the help of language. Learning scientific discourse additionally involves learning to think, act, speak and write like a scientist in a scientific community of practice.

The **"Basics of English Academic Communication for Science Majors"** course will facilitate your academic discourse socialization process by familiarizing you with essential language material (academic vocabulary, structures and patterns for several academic genres), providing you guidelines on organizing your writing process and preparing oral presentations, offering you some material for reading and discussion. This will help you develop basic academic communication skills which in their turn will provide a basis for your further academic and professional success.

Unit 1

ACTIVE READING

We live in a reading-oriented society. Much of secondary and high school as well as university instruction is reading-centered; and getting on in life after school largely depends on one's reading skills. The accumulated knowledge of humankind – from literature to logic and from physics to paleontology – is easily accessible to good readers, and virtually unavailable to poor readers. Most of what we know that is of enduring value is learned by reading from print – the thoughts, ideas and feelings of other minds. Reading can bring us a lot of pleasure. On the other hand, good reading skills are an essential prerequisite for our educational and career success. Most university students are assessed through the production of various written assignments. As your education and interests become more specialized, your writing will increasingly depend on your being informed by the knowledge of your specialized field. Your teachers and fellow students will expect you to base your statements and judgments on your ever-increasing body of knowledge, on material you have read, learned, evaluated, and built upon.

Reading and writing go hand in hand. The better you read, the better you write. In order to develop your own thoughts, you need to be able to gather information from reading; even more, you need to understand the ideas and implications of your reading so that you can respond. You have to read well enough to see what people are really discussing, what the real issues are. You need to understand what has already been written to decide intelligently what you can contribute.

The only way that your reading will affect you and stay with you is for you to react to it. Actively consider whether you agree with the ideas you read and how these ideas relate to questions you find personally important. As you read with greater care, your reactions will develop too. But whatever level you are reading at, you need to ask yourself in many different ways: What do I think about this idea? How true is it? How important is it to me? Does it challenge anything I already believe? Does it raise questions or answer questions?

When you react to your reading, you start to make a link between the ideas suggested by the page and what happens in your mind – your responses. This link is essential for any kind of intellectual work. The writer's words touch our minds; soon we will have something to say in reply. Because your reactions pass so quickly, turning your responses into words will help you hold on to them. Both writing notes in the margins of your books and keeping a reading journal will help you remember and develop your thoughts about reading. Thus the reader becomes a writer.

ANNOTATION

The way to begin sorting your first reactions to your reading is to put them in words – either by talking or by writing. However, you may not always have a friend at hand. A more realistic practice is to confide in yourself, writing down your thoughts, reactions, and questions as they occur to you in the margin of your book – next to the passage that triggered the response. When you reread the book at a later date, you will know· what you liked and what you did not, what reminded you of a personal experience, and which ideas stimulated your interest and curiosity. In case you were not sure just what you thought back then, you can sort out the many directions of your earlier thoughts when you return for a second look.

With pencil in hand, ready to comment on your reading, you may find you want to make two different kinds of remarks: some to help you understand the meaning of the text more fully and others to express your own reactions, evaluations, and associations. It is a good idea to keep the two kinds of comments separated. For example, you may put comments on the meaning in the narrower margin near the book's spine and leave all the other margins for reactions.

Annotations to clarify. You may use annotations for meaning as a study technique. Underlining key statements, numbering supporting arguments, defining unusual words, and paraphrasing difficult passages all help you approach the surface meaning of a text. But annotations can go more deeply to establish the connections and logic of the entire selection. In the margin you can explicitly state underlying assumptions of the text – that is, ideas only indirectly suggested by the original. Where the meaning of words or structure is unclear, a well-placed question mark even better, a purposeful question will remind you of what is puzzling.

Annotations to evaluate. On the second level of annotation, your thoughts interact with the ideas suggested by the text. Feel free to express the most outrageous opinions in the most informal way. Probably no one but you will see these comments, so allow yourself freedom. Any type of phrase, mark, smudge, or sign that conveys your attitude is legitimate. With this freedom you will eventually find your own topics, your own things to say. Here you can see some typical kinds of comments that may help you to get started:

approval and disapproval	*????, NO!, not bad, exactly, yeccch, nonsense, right*
disagreements	*I can't agree because ..., no, the actual facts are...*
exceptions	*this doesn't hold for the case of...*
counterexamples	*isn't case x just the opposite?*
supporting examples	*this is exactly what happens in case y*
extensions	*this could even apply to...*
discoveries	*this explains why...*
possible implications	*would this mean that..?*
personal associations	*my uncle acts just like that...*
reading associations	*Z in his book argues the same thing*
distinctions	*but it's not like Z's argument because...*

As soon as you get into the spirit of annotation, you can throw out all these suggestions and develop comments most appropriate to the way you think.

PRACTICE

1. *Read the following passage and annotate it to clarify*

Until recently, most scientists did not take longevity research very seriously. Even today, in many parts of the scientific community, anti-aging research is viewed as science fiction posing as science. But scientists at some of the most prestigious universities and biomedical research institutes in the world are looking for ways to extend the length – and improve the quality – of human life. While few of these scientists confidently predict that their work will end aging or dramatically prolong the human life span, many are cautiously optimistic about the prospect of making significant progress in the coming decades.

Scientists do not know exactly why people age and die. They understand many of the mechanisms that lead the body to break down and stop working over time, but the underlying causes of aging are still a mystery. One popular theory holds that humans are essentially programmed to die after they are no longer needed to raise the children they produce. According to this theory, evolution has ensured that people are strong during their fertile years so they can produce and rear offspring, but this bodily vigor subsides after the reproductive and parenting years are over.

In the last 200 years, advances in medicine, nutrition and public health have substantially increased human life spans. But these increases have been achieved largely by helping more children live to adulthood and old age rather than by pushing the boundaries of human aging well past their known limits, which most experts put at about 120 years.

Today, a host of companies offer different treatments, from human growth hormone (HGH) to testosterone, aimed at helping people turn back the clock. But these therapies have been widely shunned by the mainstream medical community and, so far, they have not been scientifically shown to lengthen a person's life span in any meaningful way. Some, like HGH, are alleged to be detrimental to long-term health.

Most gerontologists predict that the average life span in the developed world will continue to grow steadily and slowly. For example, in the U.S., life expectancy is projected to increase from roughly 78 today to 83 in 2050. In addition, the number of people who live past 90, or even 100, will continue to grow rapidly. Without a doubt, the world is getting grayer.

2. *Annotate the texts below to evaluate. Include comments about the following: Are the facts true? Do I agree with the opinions? Is the information trustworthy?*

a) Global warming affects most people in the world, especially those living in the low-lying areas near the sea. It has been predicted that the melting of polar ice may cause the sea to rise by as much as twelve metres by 2050. This would cause flooding in many major coastal cities, such as Tokyo. It has been suggested that the best solution to this problem may be for mankind to become amphibious, like frogs. It is argued that life was originally found in the sea, and so it would merely be a return to our original habitat.

b) There is significant new evidence of the effects of heavy alcohol consumption by young people. In Britain in 2010 nearly 800 people under 44 died from cirrhosis of the liver, a condition that is mainly caused by excess drinking. This is over four times higher than the number in 1980. The growing problem seems to be due to "binge" drinking among the young, when drinkers deliberately set out to get drunk. As a result the government is studying the possibility of compulsory health warnings on alcohol advertising.

READING RESPONSE JOURNALS

Sometimes your comments may outgrow the limits of the margin. The reading response journal provides the space for more extended ideas – and especially for ideas not tied to any particular passage of the original. A reading journal is a diary of your thought processes. After each session of reading, you simply start writing about your most dominant or curious impressions, just as in a diary. The journal is only for your own use, so you need not worry about shifting the topic, contradicting yourself, losing sense, or being unconvincing. Correctness of language and problems with spelling should not bother you. Just put down your first reactions and explore them until you have worked them out fully.

Until you become comfortable with keeping a journal, you may be at a loss as to how to begin a day's entry. One technique for getting started is to freewrite about those parts of the reading assignment that most impressed you, either positively or negatively, then try to explain why they made that kind of impression. **Freewriting** is an unstructured and informal record of the writer's thought processes. Let your thoughts come and write them down for a set period of time, such as five to ten minutes, without analyzing or editing them. When readings do not evoke immediate responses and you find yourself hard-pressed to write anything in your journal, freewriting can provide a way in. You do not have to worry about wandering too far from the subject. Eventually you will find yourself back on track with an interesting insight or observation.

Writing in a response journal is a free and creative activity. In this process you will apply different strategies depending on your mood, interests, interpretation of a particular piece of reading, etc. While journaling you may try a variety of responses to your reading. Here are some of them:

1. **Question**: Jot down questions about anything in the text that confuses you or seems unclear. You can question anything from the use of a single word to the meaning of an entire paragraph. Whenever possible, try to answer your question based on your interpretation and comprehension of the text, even if you do not think you are "right".
2. **React**: Express your personal reactions to the writer, participants, information or ideas presented in the text. What do you like? What makes sense? What makes you angry? What bores you? What makes you sad? What makes you happy? Readings, especially primary documents and narratives should be "felt" not just understood.
3. **Relate**: Try to relate what you read to what you already know about ideas, people, the time period, personal experiences, historical events, future outcomes, etc. The more connections you can make with the reading, the more meaningful the reading will become.
4. **Reflect**: What thoughts or associations does the reading inspire within you? What do you now think or believe that you did not think or believe before you read this work? What significance does the reading have for you personally?
5. **Monitor your understanding**: Note when you get bogged down in your reading or lose track of what the author is saying. How did you get over your impediments to reading and understanding? When were you

successful in comprehending and enjoying what you read? What parts of the reading were easy? Satisfying?

6. **Anticipate**: Active readers always try to predict what will happen next or in the future. Try to think how conflicts or problems within the reading will be resolved.
7. **Construct and revise hypotheses**: Making sense of any reading requires making and remaking hypotheses. Based on initial information, we form expectations about how events will unfold, what the author has in mind, etc. As we read on, some of our hypotheses will be revised and some will be confirmed. Track your initial hypotheses and record their evolution as you read.
8. **Evaluate**: Do you like what you are reading? What are the good and bad points of this work? How could it be improved? Does it have something valuable to say? Is it worthwhile reading?
9. **Prioritize**: What word, passage or idea is most important? Why?
10. **Organize**: Create a chart, diagram, map to help organize ideas, characters, places, key points from the reading. Briefly explain the purpose and structure of your creation.
11. **Create**: Compose a work of your own (essay, story, cartoon, artwork, etc.) in response to the reading. Explain how your creation relates to the reading and was inspired by the reading.

If you find it difficult to put your thoughts into words in the beginning, the following starters might be helpful:

Asking questions:	**Reflecting:**
I wonder why… *What if…* *How come…* *How is it possible that…*	*So, the big idea is…* *A conclusion that I'm drawing is…* *The author is trying to make me (see, feel, do)…*
Monitoring understanding:	**Relating:**
At first I thought.., but now… *My latest thought about this is…* *I'm getting a different picture here because…* *I lost track of everything except…* *I know I'm on the right track because…* *I need to reread the part where…* *A term or idea that was unclear to me was…*	*I already know that…* *This reminds me of…* *This relates to…* *I experienced this once when…* *This is relevant to my life because…* *The argument here is similar to… because…* *I can relate this to other readings because…* *Another example of is…*

Predicting:	**Visualizing:**
I'll bet that… *I think…* *If…, then…*	*I can picture…* *In my mind I see…*
Reacting and interpreting:	**Evaluating:**
What this means to me is… *I think this represents…* *The idea I'm getting is…* *One question that this text addresses is…* *A golden line for me is…* *This word/phrase stands out for me because…* *I like how the author uses… to show…*	*I like/don't like… because…* *The idea I find most provocative is…* *This could be more effective if…* *I reject this author's view because…* *The most important message here is…*

There are no rules about journal writing, it is very individual. Still a few most common types of journal entries can be described.

Notes-and-Response Entries

Sometimes your reactions to readings may be limited by how much (or how little) you know about their subject matter. In these instances, you may need to be sure you comprehend the reading before you write a response. A notes-and-response entry begins with notes that present the main ideas from the passage. Then you start to develop your ideas in response to each of those points. Because notes-and-response entries are more structured than freewriting, they may help you tackle difficult reading assignments or assignments that you find it hard to get involved with.

The following entry was written by a student who annotated a section "Life Extention and Faith" (*see pp. 110-112*) in David Masci's essay "To Count Our Days: The Scientific and Ethical Dimensions of Radical Life Extension".

notes:	*response:*
1) Abrahamic religions - (Judaism, Christianity, Islam) view death as God's punishment for human disobedience to Him	*1) I wonder if all three Abrahamic faiths would have a negative attitude to radical life extension? Why should they show different reactions if they rely on the same postulate about death as a result of the humanity's fall?*

notes:	response:
2) The Roman Catholic Church expressed concerns about society's "aged paralysis"	*2) Why does Benedict XVI believe that refusal to have children will necessarily result from life extension? What if this supposition is wrong? Will the Rom. Cath. Church change their attitude to life extension?*

Question-and-Answer Entries

In question-and-answer entries you write a series of questions about the meaning, implications, and value of the reading. Then you choose one question from your list and start writing an answer. If you run out of ideas to include in the answer, you can turn your last sentence into a new question by putting What, How, or Why at the beginning. This last kind of entry can be called a pursuit entry, because you pursue your ideas and responses by constantly questioning your responses.

Below you can see a question-and-answer entry written by another student in response to the same passage.

1) I wonder if Judaism, Christianity and Islam would react to radical life extension in the same way?

No. Catholics will approach the idea with reservations and concerns about changes in the society due to its ageing. Protestants will be worried about the moral issues of living longer because of possible involvement of cloning techniques and use of embryonic stem cells. Jews will welcome the prospect of longer lives as an opportunity to serve God better. Muslims will accept life extension as God's plan for people.

2) How will non-Abrahamic religions such as Buddhism and Hinduism interpret the prospect of life extension?

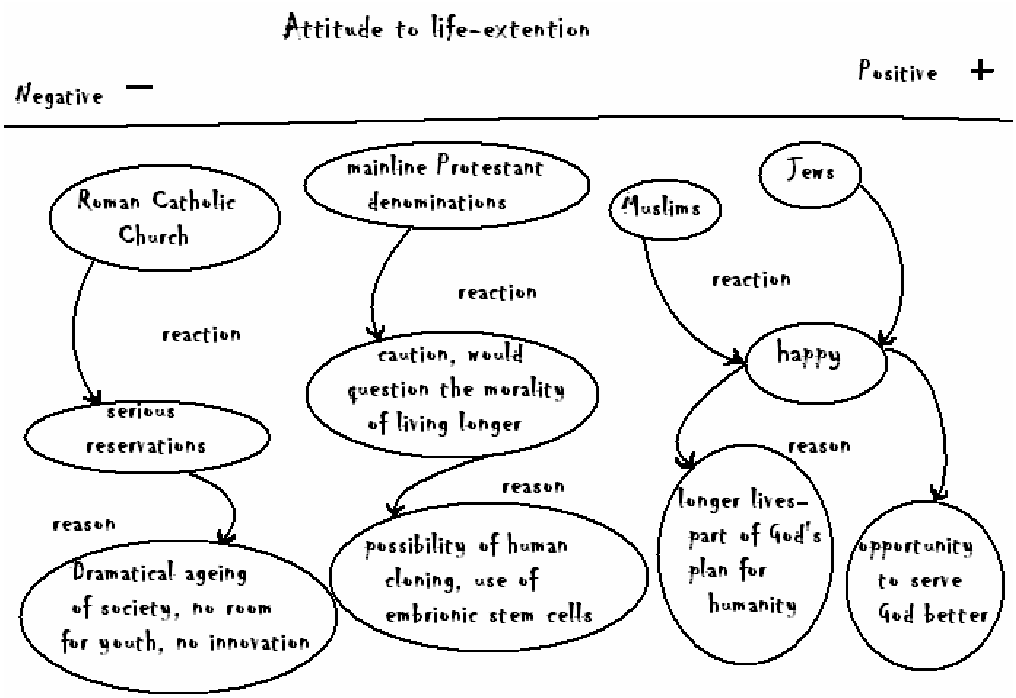
Positively. For Buddhists it's additional time to learn wisdom and compassion to achieve Nirvana. For Hindu it's a return to the "golden age" when people lived 400 years.

Multimedia Entries

Often we think and respond in ways that are not always easily captured in words. A reading may suggest a visual image to us, or a set of feelings, or a network of associations. Drawing a cartoon or picture may help us capture the feelings or imagery through which we are relating to the ideas in a book.

Creating a cluster or a diagram or a chart can help us put together a network of associations and relations among ideas. Sometimes, drawing a picture or making a graph just breaks up the monotony of more conventional journal entries and thereby allows us to think more creatively.

Here you can see an example of multimedia entry visualizing the information from the same piece of text as the two previous sample entries.



Journals can serve many purposes. The type of journal called a **Learning Log** is particularly helpful in the academic setting. In learning logs students reflect on learning experiences they take part in. They can respond to questions they have about the experience or content, reflect on how well they understand the presentation, connect the material to their own lives, or comment on their interest in the content.

Journals, in addition to helping you understand and respond to reading assignments and learning experiences, can also provide a space for you to test out new ideas. In exploring your ideas informally in a journal, you may discover an idea you want to expand into an essay. An idea just starting to emerge in rough form may show promise of fuller and more orderly expansion. Therefore, it is worthwhile to reread your journal before writing on a subject you have been exploring.

Keeping a journal for any course with a lot of reading helps you remember the material and develop thoughts on it. The journal can become the place where you start to fit together the pieces in the puzzle of your education. It can also be where you discover the abiding intellectual questions you will carry with you for the rest of your life.

PRACTICE

1) *Choose a text from the* ***Reading Bank*** *and write three different kinds of journal entries for it – for example, a five-minute freewriting entry, a notes-and-response entry, and a drawing or diagram. After you have completed these entries, read through them and write a paragraph comparing the ways your ideas developed in the different formats.*

2) *Select reading material on issues in science that are of interest to you from scientific journals, newspapers, magazines, and other sources. This will provide you with material for your further work on writing and speaking. As you read those texts, keep writing your reader journal adding new entries at least twice a week. Use your notes for the assignments you will be given later on this course.*

Unit 2

ACADEMIC WRITING

Academic writing comprises a great number and variety of genres of different length and complexity from short written examination essays to master's theses. It also involves different degree of writers' independence and authority in expressing their voices such as in summarizing someone else's text, reviewing a book or writing one's own research paper.

This introductory course will familiarize you with the genres of academic writing that you will most probably have to deal with throughout your university program. These are summary and critical review, academic essay, conference proposal as well as the essentials of a research paper. You will also be provided with references to both printed and web resources which will help you further develop your academic writing skills on your own.

SUMMARY

The ability to write an effective summary might be the most important writing skill a university student can possess. You need to be able to summarize before you can be successful at most of the other kinds of writing that will be demanded of you at university.

Summary allows you to reproduce another writer's thoughts — but in shortened form. In writing a summary, you focus on the most important statements of the original passage and eliminate the less important material. To rewrite a longer piece in short form, you must first understand the piece you are working with. Begin by reading the piece carefully, making sure you absorb the full meaning. Once you understand the piece you are summarizing, you must decide which parts you are going to include in the summary and which you are going to leave out. Because a summary moves quickly through the main points of the original, you need to focus on the most important ideas and details and leave out less important material. In preparing to write your summary, you can identify important material by underlining, circling, or highlighting it and eliminate less important material by deleting it — crossing it out.

The key to writing an effective summary is combining the material you choose to include into concise, coherent sentences and paragraphs. Because you are taking information from many parts of the original text, you could easily lose sight of the logical structure of the whole piece. You need to pay close attention to the new transitions and paragraph structure of the summary. Finally, be sure you identify the source of the original material in a heading, an introductory phrase, or a footnote. So, the main steps in writing a summary are as follows:

- read the original text carefully and check key vocabulary;
- choose material for the summary, underline or highlight the key points;
- make notes of these taking care to use your own words;
- write the summary using the notes, re-organizing the order of ideas where necessary;
- check the summary to make sure no important ideas have been omitted or distorted.

Although a summary is a miniature copy of the original text, it repeats the ideas of the source in different words and phrases. Thus, the ability to paraphrase is an important tool for writing good summaries. The value of paraphrasing goes beyond its usefulness for summarizing. Paraphrasing helps you to grasp the full meaning of the original source better and allows you to borrow ideas from other authors in a legitimate way, so that you can avoid plagiarism. More practice on paraphrasing will be offered later in the section dealing with the problem of plagiarism. Here you can see an example of how an original passage can be paraphrased and summarized.

The original passage:

Students frequently overuse direct quotation in taking notes, and as a result they overuse quotations in the final [research] paper. Probably only about 10% of your final manuscript should appear as directly quoted matter. Therefore, you should strive to limit the amount of exact transcribing of source materials while taking notes. *Lester, James D. Writing Research Papers. 2nd ed. (1976): 46-47.*

A legitimate paraphrase:

In research papers students often quote excessively, failing to keep quoted material down to a desirable level. Since the problem usually originates during note taking, it is essential to minimize the material recorded verbatim (*Lester 46-47*).

An acceptable summary:

Students should take just a few notes in direct quotation from sources to help minimize the amount of quoted material in a research paper (Lester 46–47).

PRACTICE

1. *Read the following text and compare the summaries. Decide which one is best giving reasons.*

Researchers in France and the United States have recently reported that baboons are able to think abstractly. It has been known for some time that chimpanzees are capable of abstract thought, but baboons are a more distant relation to mankind. In the experiment, scientists trained two baboons to use a personal computer and a joystick. The animals had to match computer designs which were basically the same, but had superficial differences. In the experiments the baboons performed better than would be expected by chance. The researchers describe their study in an article in the *Journal of Experimental Psychology*.

a) French and American scientists have shown for the first time that baboons have the ability to think in an abstract way. The animals were taught to use a computer and then had to select patterns that were similar, which they did at a rate better than chance.
b) Baboons are a kind of monkey more distant from man than chimpanzees. Although it is known that chimpanzees are able to think abstractly, until recently it was not clear if baboons could do the same. But new research by various scientists has shown that this is so.
c) According to a recent article in the Journal of Experimental Physiology, baboons are able to think in an abstract way. The article describes how researchers trained two baboons to use a personal computer and a joystick. The animals did better than would be expected.

SUMMARY ESSAY

At university you may also be asked to write another type of summary, the summary essay, which is written for an audience other than yourself. The purpose of the summary essay is to convey to others an understanding of a text you have read, without their having to read it themselves. Thus for your readers, your summary essay functions as a substitute for the source that you are summarizing. You must represent your source accurately and comprehensively, with as little of your own interpretation as possible. Another reason why teachers sometimes assign summary essays is that they want to make sure students fully understand an assigned source. A summary essay should be organized so that others can understand the source or evaluate your comprehension of it. The following format works well:

The introduction (usually one paragraph) which

1) contains a one-sentence thesis statement that sums up the main point of the source;
2) introduces the text to be summarized:

(i) gives the title of the source;
(ii) provides the name of the author of the source;
(iii) sometimes also provides pertinent background information about the author of the source or about the text to be summarized.

The introduction should not offer your own opinions or evaluation of the text you are summarizing.

The body of a summary essay (one or more paragraphs) which paraphrases and condenses the original piece. In your summary, be sure that you

1) include important data but omit minor points;
2) include one or more of the author's examples or illustrations (these will bring your summary to life);
3) do not include your own ideas, illustrations, metaphors, or interpretations. You are simply repeating what the source text says, in fewer words and in your own words. But the fact that you are using your own words does not mean that you are including your own ideas.

There is customarily no **conclusion** to a summary essay. When you have summarized the source text, your summary essay is finished.

Below is a sample essay followed by an example of a summary essay.

So that nobody has to go to school if they don't want to

by Roger Sipher

A decline in standardized test scores is but the most recent indicator that American education is in trouble.

One reason for the crisis is that present mandatory-attendance laws force many to attend school who have no wish to be there. Such children have little desire to learn and are so antagonistic to school that neither they nor more highly motivated students receive the quality education that is the birthright of every American.

The solution to this problem is simple: Abolish compulsory-attendance laws and allow only those who are committed to getting an education to attend.

This will not end public education. Contrary to conventional belief, legislators enacted compulsory-attendance laws to legalize what already existed. William Landes and Lewis Solomon, economists, found little evidence that mandatory-attendance laws increased the number of children in school. They found, too, that school systems have never effectively enforced such laws, usually because of the expense involved.

There is no contradiction between the assertion that compulsory attendance has had little effect on the number of children attending school and the argument that repeal would be a positive step toward improving education. Most parents want a high school education for their children. Unfortunately, compulsory attendance hampers the ability of public school officials to enforce legitimate educational and disciplinary policies and thereby make the education a good one.

Private schools have no such problem. They can fail or dismiss students, knowing such students can attend public school. Without compulsory attendance, public schools would be freer to oust students whose academic or personal behavior undermines the educational mission of the institution.

Has not the noble experiment of a formal education for everyone failed? While we pay homage to the homily, "You can lead a horse to water but you can't make him drink," we have pretended it is not true in education.

Ask high school teachers if recalcitrant students learn anything of value. Ask teachers if these students do any homework. Quite the contrary, these students know they will be passed from grade to grade until they are old enough to quit or until, as is more likely, they receive a high school diploma. At the point when students could legally quit, most choose to remain since they know they are likely to be allowed to graduate whether they do acceptable work or not.

Abolition of archaic attendance laws would produce enormous dividends.

First, it would alert everyone that school is a serious place where one goes to learn. Schools are neither day-care centers nor indoor street corners. Young people who resist learning should stay away; indeed, an end to compulsory schooling would require them to stay away.

Second, students opposed to learning would not be able to pollute the educational atmosphere for those who want to learn. Teachers could stop policing recalcitrant students and start educating.

Third, grades would show what they are supposed to: how well a student is learning. Parents could again read report cards and know if their children were making progress.

Fourth, public esteem for schools would increase. People would stop regarding them as way stations for adolescents and start thinking of them as institutions for educating America's youth.

Fifth, elementary schools would change because students would find out early they had better learn something or risk flunking out later. Elementary teachers would no longer have to pass their failures on to junior high and high school.

Sixth, the cost of enforcing compulsory education would be eliminated. Despite enforcement efforts, nearly 15 percent of the school-age children in our largest cities are almost permanently absent from school.

Communities could use these savings to support institutions to deal with young people not in school. If, in the long run, these institutions prove more costly, at least we would not confuse their mission with that of schools.

Schools should be for education. At present, they are only tangentially so. They have attempted to serve an all-encompassing social function, trying to be all things to all people. In the process they have failed miserably at what they were originally formed to accomplish.

(Sipher, Roger. "So that nobody has to go to school if they don't want to." The New York Times. 19 December 1997. Page 31. Print.)

SUMMARY

In his essay *"So that nobody has to go to school if they don't want to"* in The New York Times of 19 December 1997 Roger Sipher claims that American schools have failed to fulfill their primary duty of education because they try to fill multiple social functions. As a solution to the perceived crisis in education he suggests getting rid of compulsory-attendance laws in primary and secondary schools.

Six arguments are presented in support of the idea of abolishing mandatory school attendance. These fall into three groups—first that education is for those who want to learn and by including those that don't want to learn, everyone suffers. According to the author, unmotivated students "pollute the educational atmosphere" and thus discourage others from learning. The second group of arguments suggests that grades should be reflective of effort and elementary school teachers do not have to feel compelled to pass failing students. In the third, Sipher claims that schools would both save money and save face with the elimination of compulsory-attendance laws. He believes that costs saved in such a way might be used for youth centers other than schools.

PRACTICE

1. Choose one of the texts from the Reading Bank and write a summary essay for it following the format and the example above.

Unit 2

ACADEMIC ESSAY STRUCTURE

Good reading and summarizing skills are an essential prerequisite for all forms of academic writing. However, ability to comprehend and paraphrase others' thoughts is not enough for your academic success. You should be able to develop your responses to what you read and establish your own position concerning various issues in your academic essays. There are a lot of different types of essays you might be assigned to write by your college teachers. This course will familiarize you with key features of the academic essay format as well as basic principles of essay writing. You will also learn how you can respond to your reading in the argumentative (opinion) essay.

In the academic setting, essays are both exercises in research and communication. Essays give you a chance to show what you can do: that you understand the question asked; that you understand the issues involved; and that you have done the appropriate amount of reading. Essays also allow you to demonstrate your analytical thinking and force a deep and powerful type of learning to take place. For these reasons, they are a common form of assessment at university.

The basic **essay structure** is represented by the following chart (figure 1)

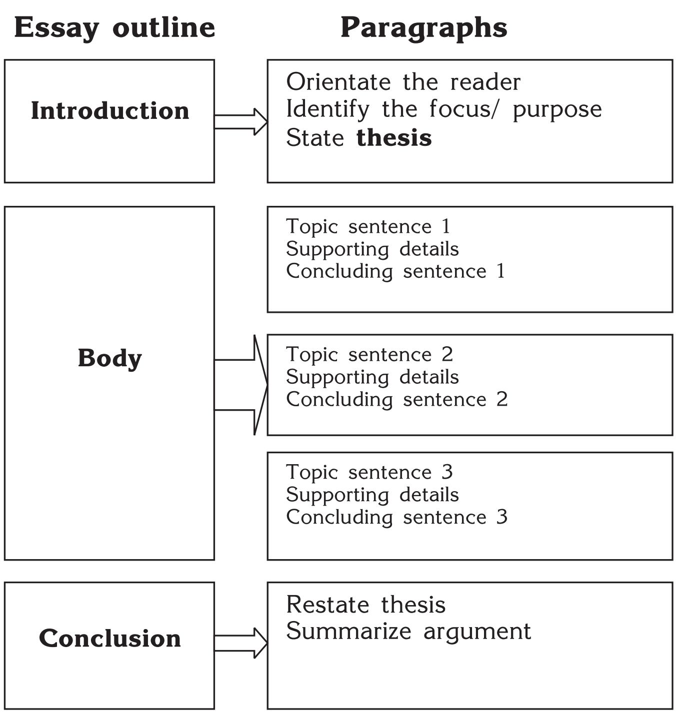


Figure 1. Academic essay basic structure

The **introduction** to your essay is an important paragraph. It is the first thing the reader sees. A good introduction should

- orientate the reader to the general topic;
- identify the focus or purpose of the essay;
- outline the scope, that is, the points to be covered, noting any limitations;
- finish by identifying the thesis.

An introduction is usually one paragraph, although this is not always the case, particularly with long essays. A **thesis statement** is your line of argument, your viewpoint. You might agree, disagree or perhaps qualify your argument in some way so that it agrees with part of the question.

The **body** of an essay is where you develop your essay. This occurs in a series of paragraphs with each paragraph logically flowing to the next. Thus a good use of topic sentences and correct paragraph structure are important.

The first sentence of each paragraph, often referred to as a **topic sentence**, introduces the paragraph by stating and summarizing the main point being made in the paragraph. Topic sentences often contain transition signals, which aid in the smooth transition from one paragraph to the next. This first sentence should inform the reader of the point you are making and how this paragraph relates to the question. In fact, if the reader were to scan your topic sentences, they should be able to obtain a sketch of the entire essay. This sketch should show the logical progression of the points you are making. Absence of topic sentences leaves the reader wondering what you are trying to say and why, ultimately confusing the reader.

Effective paragraphs have three important qualities:

- **unity**: where they focus on one main idea;
- **development**: which occurs when the idea is elaborated on in the paragraph. This elaboration usually consists of the evidence you have gathered from your research to support the point you are making in the paragraph;
- **coherence**: where everything in the paragraph relates to and expands on the point you are making.

In addition to a topic sentence and supporting sentences, body paragraphs, often but not always, have a **concluding sentence**. The topic sentence introduces the paragraph, and the concluding sentence summarizes it. However, this concluding sentence is not essential. Equally important is that the transition from one paragraph to the next should be logical and well signalled.

The **conclusion** is also an important paragraph in your essay. It is usually one paragraph in length and should reflect what you declared as your intention to do in your introduction. The conclusion summarizes what you have said in your essay and reaffirms your thesis. Do not introduce new material. Most students begin their concluding paragraph with a transition signal, such as, *'In conclusion'* or *'In summary'*.

Below you can see a sample essay analyzed. You can identify sentence (4) as ***thesis*** and sentences (5), (10) and (16) as ***topic sentences*** in corresponding paragraphs. You can also follow the relation of ideas in the ***introduction, main body*** and ***conclusion***.

The Benefits of Regular Exercise

(1) In recent years many people have become increasingly aware of the need for physical fitness. (2) Almost everywhere people turn, whether it is to a newsstand, television or billboard, advice for guarding and improving health bombards them. (3) Although much of this advice is commercially motivated by those eager to sell vitamins, natural foods and reducing gimmicks, some of it, especially that advocating a regular exercise program, merits serious attention. (4) Exercising regularly provides numerous benefits such as (A) release of tension, (B) improved appearance, and (C) increased stamina.

(5) (A) The first of these benefits, the release of tension, is immediate. (6) Tension builds in the body because of an overaccumulation of adrenaline produced by stress, anxiety, or fear. (7) Doctors agree that performing calisthenics or participating in an active sport such as tennis or volleyball for thirty minutes releases tension. (8) If a person swims, jogs or rides a bicycle for half that time, he or she should sleep better at night and have a better temperament the next day. (9) In addition, after the release of tension, petty irritations and frustrations will be less troubling.

(10) (B) An improved appearance, which is a second benefit of regular exercise, is not as immediately apparent as a better disposition. (11) Exercise takes perhaps a month or longer to show its results in a trimmer, firmer figure. (12) Improvement, however, will come. (13) Most excess fat will be burned and muscles will tighten, thereby reshaping the physique. (14) Combined with a sensible diet, an exercise program will also improve a person's skin tone. (15) This improved appearance will provide confidence and favorably impress others.

(16) In addition to the self-confidence engendered by an improved appearance, (C) increased physical strength produces stamina. (17) A stronger, healthier body is obviously more capable of working harder and, in fact, of withstanding normal fatigue then a tense, weak one. (18) Equally important, this stamina helps to ward off illnesses such as colds and influenza. (19) Altogether, improved endurance is one of the most important benefits of a regular exercise program.

(20) Although easy solutions to the goals of losing weight and achieving an attractive, energetic body saturate the media, actually acquiring these benefits is not easy. (21) The rewards, however, are fully worth the effort of an established exercise program that (A) makes a person feel relaxed, (B) look healthy, and (C) have adequate strength for strenuous as well as routine activities.

PRACTICE

1) *Read the following essay and divide it into paragraphs. Indicate the thesis in the introduction and topic sentences in the main body. Show how ideas are interrelated across paragraphs as it is done in the model above.*

Knowing How to Live Alone

(1) Most people are terrified of living alone. (2) They are used to living with others – children with parents, friends with friends, husbands with wives. (3) However, chances are high that most adult men and women will need to know how to live alone, briefly or longer, at some time in their lives. (4) To avoid being driven to despair by loneliness when this time comes, people should face up to reality and prepare themselves for living on their own both physically and emotionally. (5) By learning to deal with challenges of self-dependent life one will increase his or her self-assurance and find ways to start new relationships. (6) One good way to prepare for living alone is to learn how to take care of practical matters. (7) For example, some students and newly single people might not know how to do something as simple as opening a checking account. (8) Similarly, making major purchases is something people living alone might have to handle. (9) But how long can a person manage with a refrigerator that cannot be repaired or a car that will not run? (10) After shopping around and making price comparisons, most people find that these decisions are much less complicated than they seem at first. (11) The confidence that single people get from learning to deal with practical matters can boost their chances for establishing new friendships. (12) When singles feel self-reliant, they can have an easier time getting out and meeting new people. (13) For instance, some students are in the habit of always going to classes with a friend. (14) When they break this dependency, they can be pleasantly surprised to find that they can concentrate better on the course and also have a chance to make some new friends. (15) Probably the most difficult problem for people living alone is dealing with feelings of loneliness. (16) It is important not to confuse being alone with feeling lonely and remember that anyone can suffer from loneliness in a room crowded with friends. (17) People living alone have to fight any tendencies to get depressed. (18) Getting involved in useful and pleasurable activities, such as volunteering their services to help others, might be very helpful. (19) People need to ask themselves, “If I had to live alone starting tomorrow morning, would I know how?” (20) If the answer is “No,” they need to become conscious of what living alone calls for. (21) People who face up to life usually do not have to hide from it later on.

ESSAY WRITING PROCESS

Writing involves more than just taking a pen in hand and expecting words to flow perfectly onto paper. It requires much time and effort even from professional writers. Whatever you write, your main goal is to get your message across to the reader as effectively as possible. To achieve this goal, it is important to understand that writing is a process consisting of specific steps that help writers produce clear, correct and interesting texts. Experts who have studied what people do when they write have found that the writing process usually consists of five steps. These steps are described below, as they apply to writing assignments you may need to complete at university.

Step 1: Analyze the question

Some questions are written in such a way that the content and structure of the essay is outlined in the essay question. This often occurs in a long question, so don't be put off by the length of the question.

However, other questions require that you first analyze the question to determine the direction that is required and the level of analysis needed. When this occurs, the following key word analysis will help ensure that you answer the question.

1) Look for the **content words** that determine what you will need to research: that is, what you are expected to write about. Pay attention to words that indicate the **general topic** (this often assists you with a good introductory sentence for your introduction) and the **focus of the question** (this is, what the lecturer wants you to specifically address).
2) Note the **task,** or **directional words**, which will dictate how you are expected to approach the question. These are sometimes contained within the instructions leading up to the question. Task words are important because they determine the depth of analysis or thinking required. Here are some examples of task words: *describe, explain, outline, enumerate, compare, contrast, analyze, discuss, explain, illustrate, interpret, evaluate, justify, prove, express your point of view.*

Step 2: Research

After you have analyzed and understood the assignment question you might be able to **formulate an initial plan** by brainstorming, that is, jotting down your ideas so far. Concept mapping works well when brainstorming. An initial plan will help guide your reading and note-taking. However, it is more likely that you will need to research the question in more detail before you can go much further. You will be required to read widely. Reading requirements will also vary between subjects and the topics. Some topics may require a detailed analysis of a small number of texts; yet it is rarely sufficient to read only one or two books on a particular topic. After having found the information you are looking for, your task is to take effective notes. Remember to take the full reference including any page numbers. You will need this information if you decide to use this research in your essay.

Step 3: Plan

You are now ready to plan your essay, or if you had an initial plan, return to it and add any new points or delete any that you have now discovered are irrelevant.

Planning however does not simply mean randomly gathering information to support your argument. Planning involves grouping or categorizing information into a series of points and determining a logical order in which to present your points. Your aim is to develop a logical, coherent and transparent structure. The following steps will help you do this:

- Formulate your thesis: Did you start your research with a thesis? Has it changed now that you have researched the question further? Or have you developed a thesis now that you have researched your topic? What is your thesis or viewpoint? Remember, your thesis will help you structure your essay.
- Decide which points you wish to include in support of your viewpoint or thesis.
- Check to see if there is a logical grouping of ideas or points.
- Decide on an order of presentation. Order could be determined by, for example, level of importance, time in place, the question, geography or personal preference, but it should follow the order indicated in the introduction.
- Delete any points that you now consider irrelevant.

Step 4: Write

- Refer to the section on essay structure.
- Follow your plan.
- Remember to pay attention to your topic sentences. Make it clear to the reader what point you are making in each paragraph and why.
- Relate the points you are making to the question or your thesis.
- Do not use any colloquial phrases, informal language or clichŭs.
- Use full sentences to communicate your ideas.
- Always reference other people's ideas whether you paraphrased or directly quoted their work.
- Remember this is a draft. Come back later and edit out minor errors.

Step 5: Edit

This is the final step in the essay writing process and an important one. Failing to edit your work will impact on your marks despite all your hard work. Remember, professionally presented, clear, easy to read text is the key.

Do your editing at micro and macro levels. **Micro editing** involves checking that your a) spelling, grammar and punctuation are correct; b) referencing is correct and consistent. **Macro editing** refers to examining the essay as a whole. Check for coherence and logic. In other words, does your essay make sense? Is it reader friendly? Consider one more time whether your essay answers the question in the title; think if there might be any points you left behind which would strengthen the development of your work. Put your essay aside for a day or two before you edit, otherwise you will be inclined to read what you expect to see, not what you've written. Often the best way to edit your work is to read it aloud or read it to someone. Receiving feedback on your writing is a powerful way to revise, so it is highly recommended to give your essay to someone else to read before your submit it for the final assessment. However, if you have no audience but yourself, you can make use of the list of questions compiled by Peter Elbow in his book "Writing with Power" to find out how your writing measures up to certain criteria, particularly to the criteria most often used in judging expository or non-fiction writing. You can find this list in Appendix 3 (p.)

PRACTICE

Such elements of writing as *defining terms, establishing cause and effect relationships, making comparisons, contrasting ideas, introducing examples, using cohesive devices* to organize and link parts of your text in order to make it clear and readable represent essential academic skills. Exercises that follow will help you master some of these skills.

Definitions. In academic writing, definitions are normally needed a) in introductions, to clarify a word or phrase in a title; b) to explain a word or phrase which may be either very technical, very recent, or with no widely agreed meaning.

1) *Insert suitable category words in the following definitions following the example:*

   A lecture is <u>a formal talk</u> given to a large group often used for teaching.

a) A barometer is a ______ designed to measure atmospheric pressure.
b) Kidneys are ______ that separate waste fluid from the blood.
c) Reinforced concrete is a ______ consisting of cement, sand and steel rods.
d) Recycling is a ______ in which materials are used again.
e) The mantle is a ______ of the earth between the crust and the core.

2) *Complete and extend the following definitions as in the example:*

A mortgage is a type of loan used for buying property, in which the lender has the security of the property.

a) Distillation is __________ used to __________________________________ .
b) A psychiatrist is __________who specializes in ___________________.
c) An MSc is a __________awarded on completion of __________________ .
d) Malaria is a __________caused by ___________________.
e) Wheat is a __________used for ___________________.

Examples. When writing essays it is often better to support statements by giving examples. See the following: ***Many plants and animals are threatened by global warming. In Southern Britain, for example, the beech tree may become extinct within 30 years***. The following phrases are most common for giving examples: *for example, for instance, such as, e.g., particularly, especially, the case in point is*

3) *Use suitable example phrases to complete the following sentences.*

a) As climate warms, wetland species __________ frogs may find their habitat reduced.
b) Some animals can migrate to cooler areas __________ are birds, which can move easily.
c) Many slow-growing plants, trees __________, will find it difficult to move to wetter areas.
d) Certain reptiles, __________ snakes, may benefit from dryer and warmer summers.
e) Rising sea-levels may bring some advantages __________ expanding wetland areas.

4) *Read the text below and insert suitable examples where needed.*

Students who go to study abroad often experience a type of culture shock when they arrive in the new country. Customs which they took for granted in their own society may not be followed in the host country. Even everyday patterns of life may be different. When these are added to the inevitable differences which occur in every country student may at first feel confused. They may experience rapid changes of mood, or even want to return home. However, most soon make new friends and, in a relatively short period, are able to adjust to their new environment. They may even find that they prefer some aspects of their new surroundings, and forget that they are not at home for a while!

Cause and effect. These words and phrases are commonly used as transitions for establishing cause and effect relations: *therefore, hence, thus, owing to, as, for this reason, since, because (of), as a result, due to, so, etc.*

5) Use transitions to complete the following paragraph.

Why women live longer

Some British scientists now believe that women live longer than men ____ T-cells, a vital part of the immune system that protects the body from diseases. Previously, various theories have attempted to explain longer female life expectancy. Biologists claimed that women lived longer ______ they need to bring up children. Others argued that men take more risks, ______ they die earlier. But a team from Imperial College think that the difference may be ______ women having better immune systems. Having studied a group of men and women they found that the body produces fewer T-cells as it grows older ______ the aging process. However, they admit that this may not be the only factor, and ______ another research project may be conducted.

Below you can see more cohesive devices used for various purposes in academic writing:

to list ideas and organize text	first, in the first place, first of all, to begin with, second, in the second place, secondly, third, in the third place thirdly, next, another, finally, last
to add information	moreover, furthermore, besides, also, further, too, and, in addition, additionally, likewise, again, equally important
to compare and contrast ideas	likewise, in comparison, to compare, in the same way, as well as, like, correspondingly, just as, similarly; in contrast, on the contrary, although, even though, on the other hand, however, as opposed to, whereas, instead, in spite of
to organize events in time	first, second, later, next, as soon as, after, then, finally, meanwhile, last, during, when, by the time, over time, until, the next step, at this stage, simultaneously, subsequently, immediately, formerly presently
to conclude	all in all, altogether, in brief, in conclusion, to conclude, in short, in summary, on the whole, to summarize

6) Read the following statements (1-8). Choose one of the patterns of organization from the list (a-h) that best describes the pattern the author will follow. Use each choice once.

a. Comparison	c. Definition and Example	e. Time order	g. Listing
b. Generalization	d. Cause and Effect	f. Classification	h. Spatial

1. ________During the election the candidate will make a number of campaign stops throughout the United States.

2.________ Managers experience several different personnel problems that must be solved before a business can work effectively such as tardiness, poor performance, and inappropriate computer usage.

3.________Just as we relate to others based on their personality traits, we tend to interact with our personal computers based on their performance.

4.________Acrophobia is an intense, unreasonable fear of high places; for example my sister is unable to go above the third floor of any building without feeling enormous anxiety.

5.________A mother's use of alcohol during pregnancy can lead to birth defects in her unborn child.

6.________Wetlands is a general term that includes several types of vital links between water and land.

7.________Within a rainforest there are four layers of growth starting on the ground and moving up through the trees.

8.________Tyler's intelligence and energy allows him to excel in a variety of areas such as sports, academics, and community service.

7) Choose the word or phrase that best completes each sentence. Use each choice once.

For example; furthermore; just as; so; during; however; for instance; even though; when; between

1. Most animals sleep in the same fashion as humans do; they relax their muscles and lie down. _____, birds and horses sleep in an upright position.

2. Jogging provides many positive health benefits for runners in their middle and senior years. _____, joggers tend to have a lower incidence of heart attacks than do non-joggers.

3. _____ Chloe is afraid of heights, she went bungee jumping to celebrate her birthday.

4. Distance education is learning that takes place when the student is in a location apart from the classroom, building, or site; _____, online courses and telecourses are distance learning courses.

5. Isabella wanted to become a professional actress, _____ she moved to New York City.

6. Jealousy destroys a friendship _____ thoroughly as a wildfire consumes a forest.

7. The best course of action to take _____ one has made a mistake is to admit it, learn from it, and avoid making it again.

8. Pilates develops a strong and supple spine by extending the space ____ each vertebra.

9. Research has shown that cancers of the lip, tongue, mouth, throat, larynx, lung, and esophagus are connected to cigar smoking. _____, facts strongly suggest a link between cigar smoking and cancer of the pancreas.

10. _____ an episode of activity, a volcano commonly displays a distinctive pattern or type of behavior.

8) Write two sentences using the words given for each type of transition.

Addition – ***another, moreover***

1____

2____

Time – ***following, then***

1____

2____

Contrast – ***on the other hand, unlike***

1____

2____

Comparison – ***equally, similar***

1____

2____

Example – ***for instance, to illustrate***

1____

2____

Cause- Effect – ***because, reason***

1____

2____

Generalization and Example – ***for example, such as***

1____

2____

9) Rearrange the order of paragraphs in the following essay.

Genetic engineering brings with it more dangers than benefits and should be banned worldwide

A) Some people consider this to be a dangerous development, and believe that all that research should be banned. Interfering with nature in this way could bring with it dangers that none of us can imagine. We have no idea how an artificially-created person might behave, or indeed how he or she might suffer. As a result, we may find ourselves in a position which we do not like, but which we are unable to reverse.

B) On the other hand, the latest research in genetics has also opened the possibility of new treatment for many diseases which up to now have been incurable. If it were possible to prevent a baby from developing a hereditary disease by modifying its genes, should we stop the scientists? If doctors could replace a diseased organ with a new one grown from cells, should it not be allowed?

C) In conclusion, I would say that genetic engineering has the potential to be both a huge benefit and a terrible curse for humankind. To make sure that we benefit from it, it will be necessary to control it very strictly. The real challenge will be to find ways of monitoring the research that is conducted in laboratories all over the world and to make sure that it is only used for the good of everyone.

D) Furthermore, many people would say that it is not for human beings to decide what other human beings should be like. It is not only people with deep religious beliefs who feel that it is wrong, for example, for parents to choose whether their baby will be a boy or a girl, or have blue eyes or musical talent.

E) Recently, advances in science have demonstrated to us that things that once seemed possible only in science fiction could become a reality. The cloning of a sheep brought the possibility of using genetic engineering to create new organs, or even whole human beings, one step closer.

READING RESPONSE (ARGUMENTATIVE) ESSAY

At university one frequent assignment is to discuss some idea you have obtained from your reading or lectures. Discussion in this situation means arguing for or against the validity, importance, or applicability of what you have been learning. The purpose of this essay is primarily educational, to help you develop your reasoning and involvement with the subject.

Your most obvious audience is usually your teacher, who only needs to be persuaded that you have developed your thinking carefully, have used appropriate knowledge of the subject, and have shown some special insight into the issues.

In the **argumentative essay** about reading, or the **discussion essay**, you present and support a direct opinion about an idea, position, or piece of information you have encountered in your reading. You need not list all your ideas, associations, and reactions to the entire piece; you need only locate one specific thought or theme to comment on.

Whether you agree or disagree with what you read depends, for the most part, on how well it fits with your image of the world. Sometimes you may not be fully aware of why you agree or disagree with what you are reading. You will have to work hard to discover your reasons to make your essay convincing. Explaining your reasons fully, giving examples, citing experiences, and referring to other ideas that you have read or simply know will help you develop a convincing argument.

To develop an argumentative essay, first read over your annotations and journal entries on the text you are going to discuss. See which comments seem the most significant and decide which of them could become the basis for your essay. Try to pick a theme that raises a significant issue in the reading and that you will be able to support and develop convincingly. Then try to formulate your agreement or disagreement into a thesis or main conclusion that will guide the overall direction of your paper. The essay should provide a single strong reaction stemming from one issue suggested by the original text. List and develop all the arguments that support your disagreement or agreement. Look deeply into why you feel the way you do, and convey to the reader in concrete and substantial detail the reasons you have. Reread the original text and your previous comments to consider whether your reaction is substantial and clearly justified. In addition, rereading the original and your first reactions may enable you to advance your ideas further and may suggest more key passages, details, and examples that you can use to develop your discussion.

After you have gathered, selected, focused, and developed your ideas, plan how this material will fit together. Although there are many ways to organize an argumentative essay, often a very straightforward pattern is all that is necessary.

The opening should include (1) the book or article that evoked your response, (2) the particular item, idea, or theme to which you are responding, and (3) a clear statement of whether you agree, disagree, or take a more complex, mixed position. The opening section should also include whatever background is necessary to understand either the idea you are responding to or your response. The substance of your agreement or disagreement should form the main body of the essay. If you have several separate points to make in support of your position, you might build a paragraph around each of these points. Carefully consider, however, the order in which you place the paragraphs so that the argument will get stronger instead of sliding downhill. No matter how you organize your essay, the reader should be able to follow the organization and ideas readily and fully. Carefully chosen examples will help the reader grasp your complete idea. Using appropriate transitions between ideas and constantly tying each point to the main idea will help the reader see how your whole essay fits together. The ending should offer a sense of completion by linking your ideas effectively in some strong statement of your position. Because this essay is responding to a text, the conclusion might recall the original idea to which you are responding, reminding the reader exactly what you are agreeing or disagreeing with.

In a reading response essay you will always refer to the original text by paraphrasing or quoting the author's thoughts. In this case you will use "author tags" to show you are talking about something in the article and not your own ideas. Author tags usually include the last name of the author and a verb. The following variations might be helpful:

(Jones) argues; suggests; explains; warns; advises; reports; implies; claims; reveals; points out; advises; questions; denies; mentions; according to (Jones)

Here you can also see some grammatical patterns used to refer the source:

- Da Souza argues that previous researchers have misinterpreted the data. Or
- As Da Souza argues, misinterpretations by previous researchers need to be corrected.
- Researchers have demonstrated that the procedure is harmful. Or
- As researchers have demonstrated, the procedure is harmful.
- Smith criticized Jones for his use of incomplete data (OR for using incomplete data).
- Both Smith and Jones condemn previous researchers for distorting the data.
- Jones describes the findings as resting on irrefutable evidence.
- Smith identifies the open window as a source of contamination.

Similar expressions and structures are widely used in reviews which will be discussed in the next unit.

PRACTICE

1) *Read one of the articles from the Reading Bank and write your argumentative essay in response.*

REVIEW

In the academic setting reviews commonly fall into several categories depending on the purpose of the review and the object being reviewed. These might be evaluation book reviews, critical journal article reviews or literature reviews. Here we shall briefly discuss the peculiarities of each format and focus more thoroughly on college book reviews.

Critical review

A critical review of a journal article is an evaluation of an article's strengths, weaknesses and validity. It is used to inform readers of an article's value through explanation, interpretation and analysis. The reviewer must present information that will allow the reader to make a value judgment about the article. Good reviews convey the content of the article, the author's approach to the subject, and the author's conclusions. They place the work in the context of its field and give a sense of the work's significance by presenting a balanced analysis of the article's strengths and weaknesses and illustrating those points with examples.

While writing a critical review one should consider the following questions:

1. Who is the author? What are his/her qualifications and authority?
2. What is the general problem area? What does the author intend to discuss? Why? Who is the intended audience?
3. What is the objective or purpose of the research? Is this clearly stated?
4. Does the author define any terms? Are the definitions specific, useful, circular?
5. What is the effect of the author's language? Does the author maintain neutrality in his/her choice of words and terms or are they emotionally charged or biased?
6. Are references given (footnotes or bibliography)? Are the references recent, important?
7. Are research methods appropriate and clearly explained? Are illustrations, tables or graphs used? Do they complement the text?
8. What are the author's major findings and conclusions? Does the author accomplish her/his objective? Has he/she overlooked anything?
9. Does the author suggest areas for further research or discussion?

Since critical reviews of journal articles are usually written by scholars in the given field and require a high level of expertise and much experience, they are not within the scope of this course.

Literature review

A literature review surveys scholarly articles, books and other sources (e.g. dissertations, conference proceedings) relevant to a particular issue, area of research, or theory, providing a description, summary, and critical evaluation of each work. The purpose is to offer an overview of significant literature published on topic.

A literature review may constitute a section of a paper, an essential chapter of a thesis or dissertation, or may be a self-contained review of writings on a subject. In either case, its **purpose** is to:

- Place each work in the context of its contribution to the understanding of the subject under review;
- Describe the relationship of each work to the others under consideration;
- Identify new ways to interpret, and shed light on any gaps in previous research;
- Resolve conflicts amongst seemingly contradictory previous studies;
- Identify areas of prior scholarship to prevent duplication of effort;
- Point the way forward for further research;
- Place one's original work (in the case of theses or dissertations) in the context of existing literature.

The **process** of writing a literature review requires four **stages**:

- Problem formulation — which topic or field is being examined and what are its component issues?
- Literature search — finding materials relevant to the subject being explored;
- Data evaluation — determining which literature makes a significant contribution to the understanding of the topic;
- Analysis and interpretation — discussing the findings and conclusions of pertinent literature;

Literature reviews should comprise the following **elements**:

- An overview of the subject, issue or theory under consideration, along with the objectives of the literature review;
- Division of works under review into categories (e.g. those in support of a particular position, those against, and those offering alternative theses entirely);
- Explanation of how each work is similar to and how it varies from the others;
- Conclusions as to which pieces are best considered in their argument, are

most convincing of their opinions, and make the greatest contribution to the understanding and development of their area of research.

Book review

A book review tells not only what is in a book but also what a book attempts to achieve and how it can be used. To discuss the uses of a book, you must explore your own reactions, for these reactions reveal how you have responded to the book. Thus, in writing a review, you combine the skills of describing what is on the page, analyzing how the book tries to achieve its purpose, and expressing your own reactions. By writing reviews, you develop your critical skills as a reader and researcher, and you master evaluative writing, which you may find useful in many situations beyond the book review itself.

Beyond a few items that must appear in a review, what you include and how you organize it is up to you. Many reviews, however, do follow one general pattern that includes all the important elements of a review.

The required items are all a matter of common sense. The reader must know what book you are talking about, so head the review with a bibliographic entry. The ideal format of this entry is as follows:

Title. Author. Place of publication: publisher, date of publication. Number of pages. Price.

The body of the review must give a clear overview of the contents of the book, the special purpose for the audience of the book, and the reviewer's reaction and evaluation. Though reviews show a wide variety of form and organization, a typical opening is a direct statement about the kind of book being reviewed and its main topic — followed by a few words of the reviewer's evaluations.

The next paragraph or section often includes background that helps place the book in context, either by describing the general problem the book addresses or by mentioning earlier books by this or another author. Here is also an appropriate place for the reviewer to discuss criteria by which to judge the book, for the context helps define what the book attempts to do. Next, a summary of the main points of the book – highlighted by paraphrase and quotation – gives an overview of the book's content. The reviewer's reactions may be included with the ongoing summary of the contents, or all evaluative comments may be saved for the end. Even if a personal reaction is withheld, the reviewer's manner of describing the contents often gives a clear impression of what he or she thinks.

In the final part of the review, the reviewer is free to carry on the discussion in a variety of ways, evaluating how well the book has achieved its goal, musing over the possibilities suggested by the book, arguing with specific points, discussing matters the book has left out, even exploring a personal experience related to the subject. In the last paragraph the book's strengths and weaknesses need to be balanced in order to unify your evaluation.

Considering the following questions will help you write a good review:

- What seems to be the author's main purpose or point?
- Is this purpose aimed at any particular group of readers?
- What information or knowledge does the book convey?
- What personal or practical meaning does the book have for you?
- What are the most appropriate terms by which to evaluate the book?
- How successful do you think the author was in carrying out the overall purposes of the book?

PRACTICE

1) *The following text is an example of a book review. Read it and discuss whether it corresponds to the review style description given above.*

Emergent Computer Literacy: A Development Perspective

Reviewed by Jeremy White, Ritsumeikan University, Japan

Emergent Computer Literacy: A Development Perspective. Helen Mele Robinson.

London &New York: Routledge, 2009, 224 pages, AUS $113.00, (Hardback), ISBN 978-0-415-96131-8

The development of children's computer literacy skills, specifically, how children acquire computer knowledge both independently and with adult guidance has been a rather marginal area not previously considered by substantive research-based studies.

Robinson's book sets out to fill this lacuna by examining how young children interact in the home context so that parents, educators and researchers can learn "effective strategies" to deal with this part of children's development. Importantly, although the focus of the book is technology literacy, Robinson confesses near the beginning that she is a more of a "digital immigrant" than "digital native" (Prensky 2001), although she has been researching computer literacy for over twenty years. A digital immigrant in this sense is someone who has not "fully assimilated with computers" and still resorts to "archaic strategies such as printing out emails". The contrast between Robinson and the group of five and six year old children growing up as "digital natives", the subjects of her research, is stark, reminding us of the "outside perspective" that teachers and parents often have. The overall effect of this juxtaposition makes for interesting reading throughout the 224 pages, which can easily be read in one or two sittings.

In the introduction Robinson argues that children born today are brought up using play stations, computers, video games, and all manner of digital technologies on a daily basis. This normalized use of technologies reflects wider expectations which assume that if children are to be functional in today's digital age they must have the ability to use ICTs (Gee 2002). Not only use them, but also use them seamlessly and without assistance. Literacy vis-a-vis educational ICTs, is therefore essential for the continued prosperity of today's world economy, a discourse that is especially powerful in the United States. Propelling this discourse forward is a wider interpretation of literacy, which has moved from an association with "one's ability to read and write" to an expanded conception which includes the ability to "read, write, speak, listen, view and think". The difference between Robinson's generation of digital immigrants and the young children under consideration in the book, pose a number of questions about the ability of adults (parents, teachers, support workers and guardians) to help scaffold children's use of technologies.

Given that only a "handful" of studies have examined the use of computers by children in the context of the home, the book focuses on this context in relation to a group of five 6-year-old children in America. Although the sample is small, the research adopts a rich mixed-methods approach using a range of ethnographic tools. Drawing on theories of learning from Vygotsky, Bandura's concept of social cognitive theory and Bronfenbrenner's ecological systems theory, the study examines three main research questions concerned with understanding parent-guided learning in the home.

One of the strong points of the book is the clear and accessible academic style which will do a great deal to broaden the appeal of this area of research beyond a narrow academic audience, so that it could be used by researchers globally as a template for how to write a research paper. The theme of the book is how early childhood learners build knowledge to be able to use hardware and software and the impact that more experienced peers or adults have on the learning process when interacting with early childhood learners. This theme is developed in an easy to understand manner over seven sections consisting of a brief introduction, in-depth literature review, outline of the research study, discussion of findings and implications, and a summary of issues and future research. This final section should be of interest to those looking to conduct research in this area, as will be the appendices, which set out the research tools in an admirably clear form.

After reading the book, researchers in the technology or early childhood area could be inspired to delve into this under-examined field of research following the paths Robinson capably opens up. Each part of the research process from the study design, setting, participants' selection, and instruments used to record data, has been explained with an in-depth approach, which will appeal to post-graduate researchers. The detailed tables are allocated next to their relevant section allowing the reader to quickly look at the information without having to move to the appendices or view them on an unrelated page. The only exception to this is the 3D graphs and charts into which too much information is often packed. Also scattered throughout the book, and especially in the appendices, are relevant research questions, instruction sheets, content analysis sheets and questionnaires that would easily enable a researcher with similar interests to know where to start to replicate this study with little or no effort.

The wider implications of the research do have some limitations as readily admitted by Robinson. The sample size for this case study is only five children. While the time spent with each child was relatively long and occurred on more than one occasion, a sample size this small leads to low levels of generalization. Secondly, the children all come from a similar socioeconomic background and all research undertaken in the book was conducted in the home setting. The book is written by a researcher from the United States, thus the governmental policies and school systems discussed are for the most part focused there, thus limiting the audience to those with an understanding of that particular system. These limitations, however, are actually an advantage as the book maps the area and highlights a number of research questions that could be developed and pursued by other researchers in other national traditions in the future.

Emergent Computer Literacy is an admirably concise study with a number of important implications for future research on children and computer literacy in the "information age". The book will enlighten both researchers and parents alike and ask them to reconsider the development of their children and their assimilation into a technologically driven society. I recommend this book to researchers and also parents as an important starting point to consider the role of the new digital literacies affecting children's education around the world. For parents in particular, here is an accessible and interesting research-based book with a potentially wide appeal.

International Journal of Emerging Technologies and Society. – Vol. 7, No. 2, 2009, pp. 127–129. Retrieved from http://www.swinburne.edu.au/hosting/ ijets/journal/ V7N2/ vo7num2-bookreview.html

2) *Following the example above write a review of a science book you have recently read.*

Unit 3
ACADEMIC WRITING AND PLAGIARISM

HOW TO AVOID PLAGIARISM

When using the words or ideas of someone else, you must give credit to your source. If you fail to identify the source of the words or ideas of someone else, you are plagiarizing. Plagiarism is a form of theft — the plagiarist steals the words or ideas of other people and claims them for his or her own. To avoid such theft, you have three options: paraphrase, summary, or direct quotation.

Paraphrase

A paraphrase is a restatement in your own words, and using your own sentence structure, of specific ideas or information from a source. Paraphrase is useful when you want to capture certain ideas or details from a source but do not need or want to quote the source's actual words. A paraphrase can be about as long as the original passage.

Use a paraphrase when (1) you do not want to interrupt the flow of your writing with another person's writing; (2) you want to avoid using a long quotation or a long string of quotations; or (3) you want to interpret or explain the material as you include it.

Here are the most important rules to be remembered if you want to avoid plagiarism when paraphrasing:

- Use your own words and sentence structure. Your paraphrase must not duplicate the source's word s or phrases.
- Use quotation marks within your paraphrase to indicate quoted material.
- Make sure your readers know when the paraphrase begins and ends.
- Check that your paraphrase is an accurate and objective restatement of the source's specific ideas.
- Immediately follow your paraphrase with a parenthetical reference indicating the source of the information.

See the following two examples of paraphrase. One of them is correct and the other is plagiarized.

Original Text: "The most effective way to write a paraphrase is to read the original passage, put the passage aside, and then compose your own restatement of the materials in the passage" (*Rosen, 2006*).

Correct paraphrase: One recommended method for paraphrasing is to read the text of interest, step away from the materials, and later restate the materials in your own words (*Rosen, 2006*).

Plagiarized paraphrase: The best way to write a paraphrase is to read the source passage, put it aside, and then write your own statement of the ideas in the original (*Rosen, 2006*).

The last example is plagiarized because the wording of the paraphrase is too close to the wording of the original. It is important to completely change the wording and the sentence structure whenever possible of an original source in order to avoid plagiarism.

When paraphrasing technical information it is important to make the language accessible to your audience. Below you can see an example of scientific text paraphrase for non-specialist audience.

Original source:

Malaria parasites have complex life cycles and, thus, distinct developmental stages, each of which has multiple antigens that could serve as targets of an immune response. A pre-erythrocytic vaccine would protect against the infectious form injected by a mosquito (sporozoite) and/or inhibit parasite development in the liver. In a previously unexposed individual if a few parasites were to escape the immune defenses induced by a pre-erythrocytic vaccine, they could eventually multiply and result in full-blown disease. An erythrocytic or blood stage vaccine would inhibit parasite multiplication in the red cells, thus preventing (or diminishing) severe disease during the blood infection. A sexual stage vaccine does not protect the person being vaccinated, but instead interrupts the cycle of transmission by inhibiting the further development of parasites once they—along with antibodies produced in response to the vaccine—are ingested by the mosquito. Transmission-blocking vaccines could play a role as part of a multi-faceted strategy directed to elimination of parasites from low-transmission areas or as a means of protecting a vaccine or drug directed at pre-erythrocytic or erythrocytic stages against the spread of resistant parasites. An optimal vaccine would have the ability to elicit protective immunity that blocks infection as well as prevents pathology and interrupts transmission of parasites, and would most likely be a combination vaccine comprised of subunits from different parasite stages.

James, Stephanie, and Louis Miller. "Malaria Vaccine Development: Status Report." National Institute of Allergy and Infectious Diseases. National Institutes of Health, 30 Dec. 2005. Web. 17 Apr. 2006.

Sample paraphrase:

The campaign to improve the health of people worldwide must continue to focus on efforts to eradicate malaria, including work on developing an effective vaccine. How would such a vaccine work? In a status report on malaria vaccines, written for the Division of Microbiology and Infectious Diseases of the National Institute of Allergy and Infectious Diseases, Stephanie James and Louis Miller describe potential types of malaria vaccines. One type would create immunity in people who have not yet been infected by malaria. A second type would prevent infected people from becoming very ill. A third would not help people who are already infected but could help stop the spread of the disease to others. The most effective vaccine would have all these characteristics – conferring immunity from infection, preventing the development of the disease after infection, and stopping the spread of the disease. (James and Miller).

PRACTICE

1) *Decide if this student plagiarized. If so, redo it so that the student doesn't plagiarize.*

Original source:

Clearly, tattooing has emerged from the underbelly to the surface of the American landscape. And as the popularity of tattoos has expanded, so has the art itself. No longer restricted to Bettie Page look-alikes' muddy blue anchors, and ribbon-wrapped hearts reading *Mom*, today's tattoo images make bold statements of personality, as individualized and varied as any art form. (xiii)

Addonizio, Kim and Cheryl Dumesnil. Introduction. Dorothy Parker's Elbow: Tattoos on Writers, Writers on Tattoos. New York: Warner Books, 2002: xiii-xvi.

The student's paraphrase:

It's a fact that tattoos have arisen from the underbelly to the top of the American landscape. Tattooing has experienced a growing popularity, and so has the art itself. It is no longer limited to sailor-style ships and blue anchors, or biker-type hearts reading "Mom." Today's images include bold statements of individualized personality as diverse as any art form (*Addonizio and Dumesnil xii*).

2) *Write a paraphrase of each of the following passages.*

1. "The Antarctic is the vast source of cold on our planet, just as the sun is the source of our heat, and it exerts tremendous control on our climate," [Jacques] Cousteau told the camera. "The cold ocean water around

Antarctica flows north to mix with warmer water from the tropics, and its upwellings help to cool both the surface water and our atmosphere. Yet the fragility of this regulating system is now threatened by human activity."

From "Captain Cousteau," Audubon (May 1990):17.

2. Of the more than 1000 bicycling deaths each year, three-fourths are caused by head injuries. Half of those killed are school-age children. One study concluded that wearing a bike helmet can reduce the risk of head injury by 85 percent. In an accident, a bike helmet absorbs the shock and cushions the head.

   From "Bike Helmets: Unused Lifesavers," Consumer Reports (May 1990): 348.

3. Whether you have morning sickness, motion sickness, or nausea from chemotherapy or radiation therapy, help may be no farther than your refrigerator or kitchen pantry. There are several foods that can help the body mitigate mild to moderate nausea. Pectin is a dietary fiber that occurs naturally in plant cell walls. Fruits such as apples, peaches, plums, and currents are good sources of pectin, as are carrots and potatoes. Ginger, also known as ginger root, is another very powerful plant that works on the digestive tract. Ginger is found in ginger ale, gingersnaps, gingerbread, and certain Chinese dishes. So the next time your stomach is feeling queasy, try reaching for a can of ginger ale, or nibbling a gingersnap cookie, an apple, or a carrot.

   From Greening, Samantha M. "Natural Remedies for What Ails You." Healthful Todays and Tomorrows 7 Apr. 2005: 18–21.

SUMMARY

Summaries were discussed previously, so now we will concentrate only on a few key points. Summary is used to convey the general meaning of the ideas in a source, without specific details or examples that may appear in the original. We normally write a summary when (1) the information is important enough to be included, but not important enough to be treated at length; (2) the relevant material is too long to be quoted fully; or (3) we want to give the essence of the material without the corroborating details.

When writing a summary you should follow these rules to avoid plagiarism:

- Write the summary using your own words. If you "borrow" distinctive words or phrases from your source, you must use quotation marks within your summary to indicate quoted material.

- Indicate clearly where the summary begins and ends.
- Use attribution and parenthetical reference to tell the reader where the material came from.
- Make sure your summary is an accurate and objective restatement of the source's main ideas, but preserve the source's tone or point of view.
- Check that the summary is clearly separated from your own contribution. One way to do this is to place the parenthetical reference immediately after your summary.

Below you can see an example of summary.

Original source:

Although the stereotypical profile of a hoarder is an older, single female, living alone and known as the neighborhood "cat lady," in reality this behavior seems to cross all demographic and socioeconomic boundaries. As hoarders tend to be very secretive, many can lead a double life with a successful professional career—hoarding behavior has been discovered among doctors, nurses, public officials, college professors, and veterinarians, as well as among a broad spectrum of socioeconomically disadvantaged individuals.

From Patronek, Gary J. "The Problem of Animal Hoarding." Municipal Lawyer May/June 2001: 6-9.

Summary:

Animal hoarders can be people from any demographic and socioeconomic group, including professionals (Patronek). Thus, agencies investigating reports of animal hoarding should be prepared to deal with people from a variety of backgrounds.

PRACTICE

1) *Read the following passage on* ***the various communicative methods practiced by animals in the wild*** *and summarize it in less than 120 words.*

Communication is part of our everyday life. We greet one another, smile or frown, depending on our moods. Animals too, communicate, much to our surprise. Just like us, interaction among animals can be both verbal and non-verbal.

Singing is one way in which animals can interact with one another.

Male blackbirds often use their melodious songs to catch the attention of the females. These songs are usually rich in notes variation, encoding various kinds of messages. Songs are also used to warn and keep off other blackbirds from their territory, usually a place where they dwell and reproduce.

Large mammals in the oceans sing too, according to adventurous sailors. Enormous whales groan and grunt while smaller dolphins and porpoises produce pings, whistles and clicks. These sounds are surprisingly received by other mates as far as several hundred kilometres away.

Besides singing, body language also forms a large part of animals' communication tactics. Dominant hyenas exhibit their power by raising the fur hackles on their necks and shoulders, while the submissive ones normally "surrender" to the powerful parties by crouching their heads low and curling their lips a little, revealing their teeth in friendly smiles.

Colours, which are most conspicuously found on animals, are also important means of interaction among animals. Male birds of paradise which have the most gaudy-coloured feathers often hang themselves upside down from branches, among fluffing plumes, displaying proudly their feathers, attracting the opposite sex.

The alternating black and white striped coats of zebras have their roles to play too. Each zebra is born with a unique set of stripes which enables its mates to recognize them. When grazing safely, their stripes are all lined up neatly so that none of them loses track of their friends. However, when danger such as a hungry lion approaches, the zebras would dart out in various directions, making it difficult for the lion to choose his target.

Insects such as the wasps, armed with poisonous bites or stings, normally have brightly painted bodies to remind other predators of their power. Hoverflies and other harmless insects also make use of this fact and coloured their bodies brightly in attempts to fool their predators into thinking that they are as dangerous and harmful as the wasps too.

Retrieved from http://www.englishdaily626.com/summary.php?005

Quotation

A quotation reproduces an actual part of a source, word for word, to support a statement or idea, to provide an example, to advance an argument, or to add interest or colour to a discussion. The length of a quotation can range from a word or phrase to several paragraphs. It is generally recommended to quote the least amount possible that gets your point across to the reader. Quoting many long passages from source material can make your paper seem choppy and can give the impression that you have no thoughts of your own.

Usually quotations are used if (1) the original writing is especially powerful, descriptive, clear, or revealing; (2) the original contains language you are analyzing or commenting on; (3) the original provides authenticity or bolsters the credibility of your paper; or (4) the original material is difficult to summarize or paraphrase adequately.

Short quotations

Observe the following rules whenever you quote (for quotations shorter than four lines):

- Copy the material from your source to your paper exactly as it appears in the original. Enclose short quotations in quotation marks.
- Provide clear attribution to your source so that your readers know the origin of the quotation.
- Immediately follow each quotation with a parenthetical reference indicating the specific source information required.

Block quotations

Use long quotations only when they are important for the point you are making and cannot be easily excerpted. As you quote, do the following:

- Set the quotation off by indenting it from the left margin.
- Begin a quotation on a new line and double-space it throughout.
- Put the parenthetical reference after the period at the end of the quotation.
- Do not enclose the block quotation in quotation marks.

DOCUMENTATION STYLES

Proper documentation obligatory includes in-text citation as well as a list of works used for all source material. The format of both depends on the documentation style you are using. A documentation style is a standard approach to the citation of sources that the author of a paper has consulted, abstracted, or quoted from. It prescribes methods for citing references within the text, providing a list of works cited at the end of the paper, and even formatting headings and margins. Different academic disciplines use different documentation styles. This chart shows the list of the most widely used documentation styles:

Style name	Sphere of application	Source
APA: American Psychological Association Documentation Style	Social sciences: Anthropology, Business and Economics, Communication studies, Criminal justice, Education, Ethnic and area studies, Geography, Law, Political science, Psychology, Sociology	Publication manual of the American Psychological Association (6th ed., 2009)
MLA: Modern Language Association Documentation Style	Humanities: Art and Architecture, Classics, Literature, Music, Philosophy, Religion, Theatre, Dance and Film, World languages and Linguistics	MLA Handbook for Writers of Research Papers (New York: MLA, 2009)
Style name	**Sphere of application**	**Source**
Chicago (Turabian) Documentation Style	World History	The Chicago Manual of Style (16th ed., 2010)
CSE: Council of Science Editors Documentation Style	Sciences: Biology, Chemistry, Computer science, Engineering, Environmental sciences, Geology, Mathematics, Nursing and Health, Physics and Astronomy	Scientific Style and Format: The CSE Manual for Authors, Editors, and Publishers (7th ed., 2006)

Nowadays plenty of Web resources providing information on each documentation style are readily available. Details on CSE documentation systems, in-text citation and reference list compiling can be found in Appendix 4 p. 207.

UNIT 4

COMMUNICATION IN THE SCIENCES

SCIENTIFIC WRITING: SPECIFIC FEATURES

In many ways, writing in the sciences is no different from writing in other fields. Both require a clear argument or thesis, careful use of evidence and sources, organization, and attention to grammar and lexis. Both also require a good deal of thought, as good writing often reflects a clear understanding of the subject. In fact, the process of writing itself can often help to formulate and solidify ideas.

However, there are also aspects of writing in the sciences that are particular to science. Writing in the sciences follows certain conventions, styles, and formats. The major forms of writing you are likely to encounter in the sciences as university students include the laboratory notebook, conference proposal, research paper, research and grant proposal. Regardless of the genre, though, all scientific writing has the same goal: to present data and/or ideas with a level of detail that allows a reader to evaluate the validity of the results and conclusions based only on the facts presented. The reader should be able to easily follow both the methods used to generate the data and the chain of logic used to draw conclusions from the data. Before we proceed to specific genres in sciences, it is worth paying attention to the key features characteristic of scientific writing in general. Understanding how the distinctive features of science writing reflect the activities and goals of science will help you become a more proficient writer of scientific prose.

Precision. Theories in the sciences are based upon precise mathematical models, specific empirical (primary) data sets, or some combination of the two. Therefore, scientists must use precise, concrete language to evaluate and explain such theories, whether mathematical or conceptual. To avoid ambiguous, imprecise writing one should be very careful about the choice of words and phrases. Figurative language, for example, similes and metaphors must be completely excluded from scientific writing. The level of detail is another important aspect. It is recommended to include as much detail as is necessary, but exclude extraneous information. The reader should be able to easily follow the methodology, results, and logic of a research without being distracted by irrelevant facts and descriptions. For the sake of precision, scientific writers use quantitative rather than qualitative descriptions.

Clarity. Concepts and methods in the sciences can often be complex; writing that is difficult to follow greatly amplifies any confusion on the part of the reader. Ability to distil complicated ideas into simple explanations is a valuable skill for an effective communicator in the sciences. For example, it is preferable to choose a more familiar term rather than an obscure one, if it doesn't reduce precision. However, in the sciences, and sometimes in other disciplines as well, technical language can be indispensable. The main function of scientific jargon is compression. Without it papers would be considerably longer, and the flow of the argument would suffer. On the other hand, if the writer cannot count on his/her readers to know what each of the technical terms means, explanations should be provided.

Science writing commonly relies on a further form of compression: replacing frequently used terms consisting of more than one word with an abbreviation, typically formed from the term's initial letters. The convention is to specify the abbreviation in parentheses immediately after the first use of the term (*e.g., the incidence of acute otitis media (AOM)*).

Appropriate sentence structure is another big challenge in scientific writing. Careful description of objects, forces, organisms, methodology, etc., required in the sciences, can easily lead to complex sentences that express too many ideas without a break point. Long strings of prepositional phrases can render sentences nearly unintelligible. There are no fixed limitations on the use prepositional phrases, but as a general rule of thumb, a single prepositional phrase is always preferable, and anything more than two strung together can be problematic.

Verbosity is not welcomed in scientific writing either. Nearly every form of scientific communication is space-limited. Grant proposals, journal articles, and abstracts all have word or page limits, so concise writing is appreciated. Generic phrases that contribute no novel information such as "*the fact that,*" "*it should be noted that,*" and "*it is interesting that*" are considered cumbersome and unnecessary.

Objectivity. The objective tone used in conventional scientific writing reflects the philosophy of the scientific method: if results are not repeatable, they are not valid. Thus, scientific writers try to adopt a tone that removes the focus from the researcher and puts it only on the research itself. Here are several stylistic conventions that enhance objectivity:

a) Active versus passive voice. Although the active voice is currently preferred in most scientific fields, the passive voice is still used. The rationale behind using the passive voice in scientific writing is that it enhances objectivity, taking the actor (i.e., the researcher) out of the action (i.e., the research). On the other hand, the passive voice can sometimes lead to confusion and is generally considered less engaging than the active voice. Some simple sentence structures help maintain the balance between objectivity and the directness of the active voice. For example:

Figure 1 illustrates the quadratic relationship between distance and *velocity.*

Experimental evidence shows that the typical dose-response curve has an inverted J-shape.
PCR analysis produced clones of the toxin B DNA originally isolated in cultures of C. difficile from hospital patients.

b) Use of "I" and "we". The use of the first-person pronouns, "*I*" and "*we,*" is becoming more acceptable in scientific discourse, particularly in proposals. However, one should be careful using "*I*" and "*we*", especially in the Methods section, and remember about certain limitations. For example, sentences should not be started with "*I*" or "*we*": this pulls focus away from the scientific topic at hand. "*I*" or "*we*" should be avoided when one is making a conjecture, whether it's substantiated or not. Everything that is said in scientific discourse should follow from logic, not from personal bias or subjectivity. It is not recommended to use any emotive words in conjunction with "I" or "we" (e.g., "*I believe,*" "*we feel,*" etc.). Using "*we*" in a way that includes the reader is also considered inappropriate.

Verb tenses. The two most common tenses in science papers are present and past. Future and present perfect rank a distant third and fourth.

Present tense is used when we are making assertions about nature or about concepts: *Turtles are bigger than beetles.*

Past tense is common in descriptions of what we or someone else did or asserted: *Darwin observed the difference in adaptability between turtles and beetles.*

Future tense is used to lay out our plan in a proposal: *In my final project, I will compare survival strategies in turtles and beetles.*

Present perfect describes what we have done repeatedly in the past continuing up to the present: *Over the past several months I have collected data on turtles and beetles.*

We can mix tenses in a single sentence, and indeed we often need to: *Darwin observed that beetles are more adaptable than turtles.*

The use of past tense in describing someone else's work is one key difference between science and the humanities. In the humanities, when we are describing what a writer, an artist, or a scholar asserted, we think of ourselves as engaging in a conversation that takes place in the eternal present: *Shakespeare compares the poet's lover to a summer's day.*

The sciences see the contribution of any individual as adding progressively to an ordered sequence of investigations. The past tense helps convey a sense of this temporal progression.

Headings. Writers in humanities are not encouraged to use headings. The opposite is true of science papers. Headings emphasize the systematic nature of scientific enquiry. They also provide an excellent organizational tool, often relieving authors of the need to create smooth transitions between the main parts of the paper. In some scientific genres, the sections and heading names are predetermined. For example, scientific studies as well as lab reports are typically divided into the following sections: Abstract, Introduction, Methods, Results, Discussion. The list may vary slightly according to the discipline, the course, or the journal. For complicated experiments, sections may be further divided into subsections, each with its own subheading. On the other hand, headings are not always obligatory. In a shorter paper, they may sometimes prove more of a hindrance than a help. Use them only if you find that they actually help you to better organize the material.

Audience. All writers should be aware of their audience. But science writers need to pay particularly close attention to audience because readers of science-related writing can have very different levels of knowledge. The key question to ask is always: Am I writing for fellow scientists or for a general audience? What your readers know or do not know will have a significant effect on both substance and style.

PRACTICE

1) *Test your scientific vocabulary. Arrange the following stages of scientific problem solving in the right order.*

- Forming the hypothesis
- Testing the hypothesis
- Designing an experiment to test the hypothesis
- Recognizing the problem
- Drawing conclusions
- Observing and recording
- Analyzing the data

2) *Test your scientific vocabulary. Choose the correct answer for each question.*

1. What is the first step in a commonly used scientific method?
   a) forming a hypothesis
   b) recognizing a problem
   c) drawing conclusions
   d) analyzing data
2. What should an experimenter do after analyzing test results?
   a) identify the problem
   b) draw conclusions
   c) carry out the experiment

d) form a hypothesis

3. What term is used to describe a conclusion based on observation?
   a) a control
   b) a hypothesis
   c) an inference
   d) a variable
4. What term is used to describe a series of carefully planned steps used to test a hypothesis?
   a) a constant
   b) an observation
   c) an experiment
   d) a conclusion
5. Why should an experiment be repeated?
   a) to form a hypothesis
   b) to reduce the chance of error
   c) to change controls
   d) to identify the problem
6. A scientist publishes the results of his experiments. Which science skill is he practicing?
   f) observing
   g) inferring
   h) communicating
   i) hypothesizing
7. What standard is used for comparison in an experiment?
   f) a constant
   g) an independent variable
   h) a dependent variable
   i) a control
8. What kind of matter description does not involve measurement?
   a) quantitative
   b) observational
   c) qualitative
   d) inferential
9. What organizes data in rows and columns?
   a) a bar graph
   b) a circle graph
   c) a line graph
   d) a table

3) Match the terms on the right with their definitions on the left. There are *three extra terms without definitions.*

a) constant b) control c) dependent variable d) hypothesis e) bar graph f) circle graph g) measurement h) inference i) observation j) science k) estimation l) technology m) line graph	1) a variable changed by the person doing the experiment 2) a graph using bars to show the relationships between variables 3) a description with numbers 4) a statement that can be tested 5) a method of making a rough measurement 6) a graph that shows parts of a whole 7) a graph using lines to show the relationships between variables 8) information you gather with your senses 9) the factor in an experiment that doesn't change 10) the factor that changes as a result of the independent variable

4) *There are many genres of writing in the sciences. Below you can see four text fragments. Decide which of the following genres they represent:*

a) conference abstract
b) course book for students
c) laboratory report
d) journal paper critique

i. ...Scientific methods are step-by-step approaches to solving problems. Steps that can be used in scientific problem solving include identifying the problem, forming and testing a hypothesis, analyzing the results of the test, and drawing conclusions. In most experiments it's important to keep everything the same except for the item or variable you are testing so that you'll know which variable caused the results. Many scientific experiments involve two variables, or factors, that change. An independent variable is a factor that the experimenter changes. The dependent variable is the factor that changes as a result of the independent variable. Constants are factors in an experiment that don't change. A control, when one is included, is a standard used for comparison. Separating and controlling variables is an important part of conducting an experiment. After studying their data, scientists are ready to draw some conclusions. A conclusion is a statement based on what has been observed

ii. **Problem addressed by the study.** According to the researcher, pre-service science teachers study a variety of constructivist learning principles and strategies in theory classes at university, and are exposed to an increasing range of exemplary online learning designs in their studies. However, he reported that they often struggle to implement theory into practice and there is good evidence that when faced with the hectic demands of everyday teaching duties, they revert to more traditional didactic teaching methods. Furthermore, he adds that their design of online activities tends to be pedagogically shallow and content driven. This study investigates possible ways of improving this situation. The study stated direct clear questions to be answered. It aimed to explore the following main research question: To what extent does pre-service teachers' authoring and use of an online learning design enhance their development as teachers? Moreover, subsidiary questions included

iii. **Methods.** This study was conducted at Yates Mill Pond, a research area owned by the North Carolina State University, on October 25th, 2006. Our research area was located along the edge of the pond and was approximately 100 m in length and 28 m in width. There was no beaver activity observed beyond this width We conducted a chi-squared test to analyze the data with respect to beaver selection of certain tree species. We conducted t-tests to determine (1) if avoided trees were significantly farther from the water than selected trees, and (2) if chewed trees were significantly larger or smaller than not chewed trees. Mean tree distance from the water and mean tree circumference were also recorded

iv. The Ashuelot Watershed is an important area in New Hampshire, containing 22 rare animal and plant species, including the Dwarf Wedge Mussel. Due to population growth and development pressures, culverts are used to connect streams under roads. As the number of roads increases so does culvert construction and use. Many of these culverts are harmful to stream systems, their organisms and their characteristics. This project focuses on eight culvert sites and their role in habitat fragmentation. Many of the researched sites adversely affect movement of wildlife and water. If the number of culverts continues to increase there will be a loss of crucial habitat areas, as well as a loss of rare species. In the near future this project will expand in order to classify each of the watershed's 1400 crossings, to undertake reparations to problem culverts.

LABORATORY NOTEBOOK

In order to become a good scientist, you must learn how to keep an accurate and up-to-date record of all experimental procedures, observations, and results. Your notebook is your own personal reference when writing a formal report or article on the experiments you have performed. The keeping of a laboratory notebook is a very important form of scientific writing and in some ways can be thought of as the cornerstone of all other types of writing.

When you keep a laboratory notebook, you also leave behind a legacy once you leave the laboratory. Anybody who follows in your experimental footsteps should be able to go to your notebook and, without additional references, repeat every single experiment reported there.

Laboratory notebooks follow a particular format described below:

Title page. Give a page to state your name, address (in case you lose the book) and a brief indication of its purpose – 'Chemistry Practicals', for example. Do not forget to number the pages – this is essential.

Table of Contents. Every experiment in your notebook must be documented in the table of contents. Reserve the first few pages of your notebook for the table of contents where you will record the following information:

- the number and title of each experiment;
- the date when the experiment was started;
- the page number where documentation for that experiment begins.

Table of Abbreviations. If you use abbreviations, you may need to give one page to list and explain them. Abbreviations are useful, as they save time and effort. It is also highly recommended to start each new piece of your work on a new page.

The **Introduction** to each experiment should include:

- *The date.* At the top of the first and all subsequent pages write out the full date (day, month, year). If an experiment is carried out over several days, it must be clear which steps in the procedure were carried out on each date.
- *Number and Title of Experiment.* The title should be descriptive, but not too wordy, for example "*Complementation and Meiotic Mapping in Saccharomyces cerevisiae.*"
- *References.* Reference any source you used to prepare for the laboratory, for example: *Hartl, D. and Jones, E. Essential Genetics: A Genomics Perspective. 3rd ed. Sudbury: Jones and Bartlett, 2002.*
- *Collaborators.* Acknowledge the contribution of your laboratory partners by including their names.
- *Purpose.* In this section, you are explaining why you are performing the experiment and how you will do it. Not only is this section useful to others who may want to replicate your work, but it can also be tremendously helpful

to researchers when they are reviewing their own work. In one paragraph, succinctly convey the goal of the experiment or the experimental question, why the experiment is being performed, how it will be carried out.

Next comes the **Experimental plan** which will include:

- *Materials.* List equipment and supplies, reagents and chemicals (even water), names of organisms used and their strains or genotypes (for biological experiments). Also include the manufacturer of a reagent or supply if a particular item can only be obtained from that company.
- *Planned Procedure.* In this section, present the procedure as you are going to perform it. List in step format. The steps can be brief, but must be descriptive enough for someone to be able to follow your directions. Also include notes about safety measures (e.g. wear gloves).

Observations and Data. The observations you make and the data that you record will lead to the acceptance or rejection of your hypothesis, and will decide what future experiments may be done. The observations and data are therefore central to the whole exercise. In this section you will include:

- *Notes and Changes to Procedure.* Make notes and observations pertaining to the experiment and anything important what happened or what you saw. Remember, someone should be able to read your notebook and do exactly what you did. Also note any deviations from your planned procedure. Be sure to make note of anything that you think may affect your results. Always make clear the part in the procedure to which you are referring.
- *Results.* This section should include any raw data that you produce during the laboratory period, such as tables, charts of colour changes of samples, photographs, drawings of observations. Anything presented in the results section should be labelled with a descriptive title and measurements should always be labelled with appropriate units.

Discussion and Conclusions section will have the following entries:

- *Data Analysis.* Here any calculations, manipulation of the data, or conclusions that you make after the laboratory period should be included. Analysis of the outcome may mean to draw a graph or calculate some value. Again, do not forget to include titles, all appropriate graph labels, and units of measurement.
- *Discussion.* In this last section, evaluate and discuss the success of the experiment. Include interpretation of your results—how you came to the conclusions presented in the previous section and whether or not your conclusions agree with any of the outcomes discussed in the *Purpose* section. What did you learn from the experiment? If the experimental

outcome contradicted expected results or produced surprising results, suggest possible reasons or address possible sources of human or equipment error. Keep in mind that sometimes unexpected results can be real and can lead to alteration of current models and ways of thinking (but only if someone else can read your notebook and repeat your experiment).

Signature. When you complete each experimental write-up, sign and date your work. Put the date that you did the calculations and finished the work, not the date you did the experiment (this should already be documented in your notebook). Cross out any remaining blank space on the last page with a diagonal line.

A sample laboratory notebook in Organic Chemistry can be seen in Appendix 2, p. 162.

PRACTICE

1) *If you do any laboratory work in the current semester, prepare a lab notebook for it in English following the format described above and the sample in Appendix 2, p. 162.*

RESEARCH PAPER

A research paper is the place where new results and ideas are communicated to other scientists. Most of the facts we learn from textbook are actually interpretations of data that were first described in the form of a research paper. A research paper is essentially an argument. In a research paper, the authors put together various observations and pieces of data to come to some sort of conclusion. It is written for other scientists, and, quite often it is written in a way that can be understood by someone educated in science though not necessarily in the field under study.

While all scientific research papers share a common organizational setup, you will find variations within the genre. The common structure of the paper is to ensure ease of reading. Researchers must quickly filter the huge amount of information available in scientific publications. A common organizational structure helps readers move quickly through reports. A typical scientific research paper will include the following elements:

- Title
- Abstract
- Introduction
- Materials and Methods
- Results
- Discussion
- References/ Works Cited

The title of a research paper should be concise; at the same time it should contain enough information that a reader can determine the relevance of the paper to their needs without reading the entire paper. In reports of an experimental nature, the specific information given in the title should include the factors being manipulated and the effects of responses being measured. Here is an example of a good title "*The Effects of Ethanol on the Compound Action Potential of a Frog Sciatic Nerve*". The title is usually centered on the page with all nouns capitalized. Authors' names appear below the title.

The abstract is a summary of the entire report that varies in length between 100 and 250 words. It includes the question investigated, the methods used, the principal results and conclusions. Abstracts are a quick way for readers to understand your research project. Thus, readers can assess the relevance of your work to their own simply by reading your abstract. As the abstract is usually the first thing that readers read, and based on that abstract, make a judgment whether to keep reading or not, the abstract is one of the most important elements of a scientific report. Although it comes first, the abstract should be the last thing you write, which will allow you to simply extract key points that you have already written in the body of the report and will ensure that you do not include any information in the abstract that is not in your research article.

Here you can see a good, polished example of a student abstract. The title is shown as well, since it is appropriate and concise. Note that this abstract is detailed and thorough, but without containing too much information.

The effect of concentration *Bradurhizobium japonicum* on the growth and nodule formation of *Glycine max*

Abstract

Concentration of Rhizobium has been shown to affect the biomass of associated legumes. This experiment through the inoculation of Glycine max by progressive concentrations of Bradurhizobium japonicum investigated the impact of Rhizobium concentration on growth and nodule formation. Four inoculums levels in 10% gradations from 100% to 0,1% were applied to six pots of four seeds each per inoculums level. Six replicates of a control receiving only deionized water as an inoculums were also grown. During the run of the experiment, height of the seedlings was measured once a week and observations were made as to the relative colour of the seedlings of various treatments. At the end of the experiment, height of each plant was measured again, the wet mass was taken of shoots and roots of the plants in each pot, and roots were checked for nodule formation. Due to time limitations on this experiment, with a run time of only five weeks, no significant data about height, colour or mass differences could be collected and no nodules were present. This is probably the result of the fact that seedlings were still being supplied with nutrients from their cotyledon leaves. Consequently there existed no environmental difference between experimental replicates, causing no differential growth based on Rhizobium concentration, or necessitating nodule formation.

The introduction is a brief section (no more than 1 page) designed to inform the reader of the relevance of your research and includes a short history or relevant background that leads to a statement of the problem that is being addressed. Introductions usually follow a funnel style, starting broadly and then narrowing. They funnel from something known, to something unknown, to the question the paper is asking. The introduction provides sufficient context and background for the reader to understand and evaluate your research; defines terms which the reader may not know. It also defines abbreviations that will be used in the report, for example, "the compound action potential (CAP)". This section develops the rationale for your work: poses questions or research problems and outlines your main research focus.

Below you can see two excerpts from student introductions. Read the first one and discuss why it is inappropriate and how it can be improved. Pay attention to grammar mistakes as well. After that, read the second proper one for comparison.

A. It is amazing to see that a big, tall plant started from a small, compacted seed. We have to wander where all this energy and mass come from that would allow a plant to be so big. From our study in ecology, we know that plant grow by absorbing water, carbon dioxide, and essential nutrients such as potassium and nitrogen. Of all the essential nutrients, nitrogen is the most important element that plants need. Plants use this to make amino acid, protein, nucleic acid and chlorophyll. Because large amount of nitrogen are needed by plant, it is known as a macronutrient. Although the atmosphere containing around 80% nitrogen, it is only available in the gaseous N_2 form, and plant cannot use it. They cannot absorb it through their leaves

B. In most ecosystems the supply of nitrogen is the most limiting factor to plant growth. Nitrogen is available to plants only after it has been fixed into NH_3^+ or NO_3^- compounds which make up a very small percentage of the total nitrogen pool in an environment. To combat this problem, leguminous plants have developed a symbiotic relationship with the nitrogen fixing bacteria, Rhizobium spp. Legumes form root nodules which house Rhizobium and

> provide the bacteria with carbon compounds, while the bacteria fix nitrogen for the plants' consumption (Adler 1995). This relationship and its mechanisms have become the center of much study, both in the physiological mechanisms and the population interactions. The formation of root nodules by the plants has been shown to be an interactive process between the plants and bacteria, occurring especially at low level of soil nitrogen (Rhijn and Vanderleyden 1995, Schultze and Kondorosi 1998). Plant and bacteria species demonstrate host specificity in forming symbiotic relationships. These relationships begin when plants release compounds, usually flavonoids, into the soil. These compounds trigger the transcription

Materials and Methods. This section describes the specific details of your work. It must provide enough information about how you performed the experiment so that it can be independently replicated in another laboratory. If a published account of a technique you used is already available you need not describe it in detail again.

Materials and methods section is always written in the past tense, as it describes exactly what you did. This part of a research paper is usually divided into subsections labeled with the appropriate subheadings to indicate a specific method (i.e., PCR or Western Blotting). Usually these subheadings are arranged chronologically based on the order of the experimental results presented in the Results section. DO NOT present or discuss your results in this portion of the article.

The following paragraph from a **Methods** section describes the data collection and statistical analysis phase of the experiment.

> To collect data on the treatments, we measured the growth and color of each plant weekly during the five-week experimental period. Measurements were taken from the middle to the end of each week. After the growing period, the plants were harvested. Each pot was harvested separately, the plants carefully removed as a group and the root ball washed to remove all vermiculite particles. The plants were then dried to eliminate excess water, and a wet weight of shoot and root were taken for each pot. The data was averaged by pot, treatment and week, and the weekly treatment means were analyzed using a t-test comparison in Excel Spreadsheet to determine if any significant data was collected. Data significance would be determined by demonstrating a difference in the effect of varying Rhizobium concentration on plant growth and mass.

The **Results** section describes but does not interpret the major findings of your experiment. Present the data using graphs and tables to reveal any trends that you found. Describe these trends to the reader. The presentation of data may be either chronological, to correspond with the Methods, or in the order of most to least importance. If you make good use of your tables and graphs, the results can be presented briefly in several paragraphs. Avoid explaining every detail of every figure. It is far better to direct the reader to a specific portion of the figure that gives the best demonstration of what you claim is your result. Remember that the essence of good scientific writing lies in its organization and the distillation of critical information.

Figures and tables provide ways to display primary data. Each figure and table should be accompanied by a legend. A well-written legend provides enough information about the figure or table that the expert reader could understand the experimental results by simply looking at the figure or table and reading the legend. In other words, figures and tables are independent units that can be understood without reference to the text.

The table that you can see below is a good example because 1) it is numbered, 2) the legend explains key details of the experiment, 3) it is clear that the error term is standard deviation, and 4) it explains the meaning of unusual abbreviations.

Table 1. Gas exchange characteristics of an Orontium aquaticum plant before and after 17 d inside a flow-through cuvette. Values are means± standard deviations. PPFD = photosynthetically-active photon flux density

	Experimental Treatment	
	Before	After
Photosynthesis (μmol $^{--2}$ s^{-1})	14.7 ± 0.7	11.8 ± 2.4
PPFD (μmol m^{-2} s^{-1})	641 ± 57	531 ± 24
Ambient [CO_2] (Pa)	38.2 ± 1.5	34.1 ± 1.6
Relative Humidity (%)	46 ± 15	67 ± 5
Number of Leaves Measured	3	5

Discussion. This is the portion of your article where you interpret the results in the context of what is known in the field. The first paragraph should summarize what you believe to be your most important results and what you believe are the best conclusions based on your findings. Then, you may go on to discuss those conclusions in the broader scientific context. Discuss the implications of your data and propose future experiments to address unanswered questions. It is important to acknowledge deviations in your data, compared to the results you expected, and explain why those deviations may exist.

The following excerpt from **Discussion** section illustrates the kinds of statements that can be made to explain the results. The author also describes possible scientific explanations for his results.

Discussion

The absence of any B. japonicum-induced root nodules on any of the treatment groups was probably related to the fact that all of the soybean plants still had their cotyledons. While the plants are drawing nutrients from these rich sources, there is no need for the plant to form a symbiosis with rhizobium. In fact, it would be to the plant's disadvantage to allow infection by rhizobium. The bacteria would be taking precious carbon from the plants that should be used for growth, without providing the plant anything it needed in return. The rhizobium-soybean relationship would become a parasite-prey relationship instead of a mutualism. To prevent this, while the plant is not in need of nitrogen, it is likely that it does not secrete the compounds that induce transcription of the rhizobium nod factors, thereby inhibiting nodule formation. Eventually, the cotyledons would have been used up and the plant could have benefited from a symbiosis with rhizobium. Premature removal of the cotyledons may have induced this response by removing the seedlings' nitrogen source, but we are unaware of what other possibly detrimental effects this could have on the soybean plants. A better situation would have been to let the experiment run past the time where the cotyledons are used up and dropped.

References. This final section lists all of the references you cited in the research paper. Every paper you cite in the text should have a corresponding reference in the References section and vice versa. The specific format of the in-text citations and the references listed in this section of the research paper varies depending on the particular journal. Information on CSE citation format, commonly used in sciences, can be found in Appendix 4 p. 207.

PRACTICE

1) *Inexperienced scientific writers may find it difficult to choose right phrases for building sentences in their papers. In this case it is helpful to study sentences from various sections in the disciplinary research journals and see what phrases are most frequently used there. Below, you can see lists of common phrases that you may use in your research paper or thesis. Decide in which of the following sections -* ***Introduction, Literature review, Methods, Results, Discussion, Conclusion*** *- they will be most appropriate.*

1.
This research has investigated… *The study set out to…* *The purpose of the present research was to…* *The study has shown that…* *An important finding to emerge in this study is…* *The results are significant in three respects:…* *In general, therefore, the results show…* *The findings add to our understanding of…* *This study adds to the body of knowledge around…* *This research confirms previous findings and contributes to our understanding of …* *However, a number of limitations need to be considered. For instance, …* *The research was limited in several ways.* *However, the findings are subject to at least four limitations.* *Several limitations need to be acknowledged.* *Further research should be done to investigate the…* *Future research should concentrate on …* *More research is needed to better understand …* *An implication of these findings is that …* *The findings of this study have a number of important implications for…*
2.
A semi-structured approach was chosen because … *This methodology has a number of advantages, such as …* *Limitations to the study design include …* *Data were gathered from …* *was prepared according to the procedure outlined by …* *The initial sample consisted of…* *The criteria for selecting the subjects were as follows: …* *To increase the reliability of measures…*
3.
A considerable amount of literature has been published on … *However, there has been relatively little literature published on …* *Numerous studies have argued that …* *Several studies have revealed …* *The research to date has tended to focus on …* *Data from several studies have identified the …* *It has been suggested that …* *Other studies have considered the relationship between …* *The first systematic study of … was reported by …* *The study of … was first carried out by …* *Detailed examination of … by … showed that …* *In a randomised controlled study of…*

A comparative study by … found that … *This view is supported by …, who argues that …* *A key problem with this argument is …* *However, there is inconsistency with this argument, given …* *X's interpretation overlooks much of …* *One question that needs to be asked, however, is …* *One problem with this approach is …* *The main limitation to X's study is …* *However, this method of analysis has a number of limitations.* *However, the research does not take into account …* *The author offers no explanation for …* *The main weakness of this study is …* *Previous studies have only focused on …* *The existing research fails to …* *Much of the recent literature has not…*
4.
It is apparent from Table 1 that… *The data in Figure 2 indicates that…* *Strong evidence of … was found when…* *A positive correlation was found between … and …* *The results, as seen in Table 2, indicate that …* *No significant reduction in … was found.* *A comparison of the two results reveals that…*
5.
… is an important component of… *Central to the discipline of … is …* *… is an increasingly important issue in …* *Recent developments in … have shown the need for …* *Recent developments in the field of … have led to a renewed interest in …* *This study builds on … and contributes to …* *Over the past century, there has been a (major) decline in …* *Recently there has been renewed interest in …* *A theoretical issue that has dominated the field for many years is …* *The controversy over … has raged for many years.* *The issue of … has recently grown in importance.* *Most studies of … have only been carried out on …* *Until now, little importance has been given to …* *Until now, this method has only been applied to…*
6.
Contrary to expectations, this research did not find a significant difference between … *This finding was unexpected and suggests that …* *Findings in the present study are consistent with the findings of …* *There are similarities in … between the present study and those described by…*

It is possible to hypothesize that ...
These findings suggest ...
In contrast to earlier findings, however, no evidence of ... was detected.
There are several possible explanations for this result. For example, ...
This inconsistency may be due to...
These data must be interpreted with caution because...
This finding, while preliminary, suggests that ...
This finding has implications for...
An important issue emerging from these findings is...

2) Use examples in Appendix 4 to list the following sources in the References section.

1. Biochar, and Its Potential Contribution to Improving Soil Quality and Carbon Capture**.** By Rhodes, Christopher J. Academic journal article from Science Progress, Vol. 95, No. 3, pages 98–112.
2. Article title: Cellulosic Biofuel Development Must Balance Need to Maintain Soil Quality. Contributors: Thompson, Stephen – Author. Magazine title: Rural Cooperatives. Volume: 77. Issue: 2 Publication date: March-April 2010. Page number: 19–20.
3. A Cubic Mile of Oil: Realities and Options for Averting the Looming Global Energy Crisis. By Hewitt D. Crane, Edwin M. Kinderman, Ripudaman Malhotra. 324 pages. Publisher: Oxford University Press. Place of publication: New York. Publication year: 2010.
4. Chapter: Behavior of cells in tissue cultures. By Warren H. Lewis and Margaret R. Lewis. Publication information. General Cytology: A Textbook of Cellular Structure and Function for Students of Biology and Medicine. Contributors: Robert Chambers – Author, Warren H. Lewis – Author, Edwin G. Conklin – Author, Frank R. Lillie – Author, Merle H. Jacobs – Author, Clarence E. McClung – Author, Ernest E. Just – Author, Albert P. Mathews – Author, Margaret R. Lewis – Author, Thomas H. Morgan – Author, Edmund B. Wilson – Author, Edmund V. Cowdry – Author, Edmund V. Cowdry – Editor, Ralph S. Lillie – Author. Publisher: University of Chicago Press. Place of publication: Chicago. Publication year: 1924. Page number: 383.

3) Find a recent research paper in the discipline of your specialization and take it to your Academic Communication class. Discuss the structure and language of the paper with your peer students.

SCIENTIFIC CONFERENCE

An important part of the work completed in academia is sharing our scholarship with others. Such communication takes place when we publish in peer-reviewed journals, books and present at scholarly conferences. This section will provide you with some insights into conference participation and preparation for it.

In order to be selected for participation you need to submit a conference proposal. The proposed topic should be oriented around the themes listed in the call for papers. You should stick to the required word limit, usually 250 to 300 words. The organizers have to read a large number of proposals, especially in the case of an international or interdisciplinary conference, and will appreciate your brevity. Make sure you submit your proposal prior to the deadline, as late submissions leave a bad impression.

A conference proposal will typically consist of an introduction to your topic, which should not amount to more than one-third of the length of your submission, followed by your thesis statement and a delineation of your approach to the problem. You should then explain why your thesis is original and innovative as well as important and interesting to scholars who might be outside your specific area of research. This portion takes up approximately three to five lines, whereas the rest (approximately another third of the total length) focuses on the conclusion that you will arrive at in your essay and exemplary evidence.

It is very important to consider your future audience in order to determine both how specific your topic can be and how much background information you need to provide in your proposal. If you would like to add a quotation to your proposal, you are not required to provide a citation or footnote of the source, although it is generally preferred to mention the author's name. Always put quotes in quotation marks and take care to limit yourself to at most one or two quotations in the entire proposal text.

Since the great majority of proposals are submitted via e-mail, make sure you follow e-mail etiquette guidelines, such as including a proper subject line, a short but professional body of text in the e-mail, preferably including a short paragraph on your scholarly background. The reader will not know your skills and qualifications and why you chose to submit to his panel or to a particular conference, so you might include a few sentences on any or all of those topics.

Below you can see two sample conference proposals appropriate for sciences.

Title: *'Culvert' Operation: Fragmentation in the Ashuelot Watershed*
Discipline: *Environmental Studies/ Geography*
Type of presentation: *Poster*

The Ashuelot Watershed is an important area in New Hampshire, containing 22 rare animal and plant species, including the Dwarf Wedge Mussel. Due to population growth and development pressures, culverts are used to connect streams under roads. As the number of roads increases so does culvert construction and use. Many of these culverts are harmful to stream systems, their organisms and their characteristics. This project focuses on eight culvert sites and their role in habitat fragmentation. Many of the researched sites adversely affect movement of wildlife and water. If the number of culverts continues to increase there will be a loss of crucial habitat areas, as well as a loss of rare species. In the near future this project will expand in order to classify each of the watershed's 1400 crossings, to undertake reparations to problem culverts.

Title: ***Dendritic Ionic Liquids: Another Step Toward Green Chemical Processes***
Discipline: ***Chemistry***
Type of presentation: ***Poster***

Volatile organic compounds (VOCs) are commonly used as solvents for industrial chemical reactions. Recently, ionic liquids have been emerging as novel replacements to VOCs due to their unique properties. Ionic liquids are liquids comprised entirely of ions that are environmentally benign, non-volatile, non-flammable, and inexpensive to manufacture. This project explores the synthesis of dendrimers that have ionic liquid properties. By incorporating ionic liquid moieties into dendritic systems, the potential exists to design a new class of macromolecules capable of catalyzing various organic reactions. The synthesis, characterization, and preliminary studies of the dendritic ionic liquids will be presented.

Conference presentations

There are several types of conference papers and sessions which you may encounter as a scholar. However, no strict division between the humanities and the sciences exists.

Panel presentations are the most common form of presentation. You will be one of three to four participants in a panel or session (the terminology may vary) and be given fifteen to twenty minutes to present your paper. This is often followed by a ten-minute question-and-answer session either immediately after your presentation or after all of the speakers have finished. In the course of the question-and-answer session, you may also address and query the other panelists if you have questions yourself.

Round tables feature an average of five to six speakers, each of whom gets the floor for approximately five to ten minutes to speak on their respective topics and/or subtopics. At times, papers from the speakers might be circulated in advance among the roundtable members or even prospective attendees.

Papers with respondents are structured around a speaker who gives an approximately thirty-minute paper presentation and a respondent who contributes his own thoughts, objections, and further questions in the following fifteen minutes. Finally, the speaker gets the same amount of time to formulate his reply to the respondent.

Poster presentations are more common in the sciences and ask participants to visually display their ideas as either an outline of findings, an essay of several pages length, or, preferably, charts, graphs, artwork, or photographic images.

Presentation strategies

Clear and logical delivery of your ideas and scientific results at conference presentations is an important component of a successful scientific career. Presentations encourage broader dissemination of your work and highlight work that may not receive attention in written form. The rules of making a good presentation apply broadly across disciplines and now we shall consider some of them.

- ***Prepare your presentations to address the target audience***. Be sure you know who your audience is—what their backgrounds and knowledge level of the material you are presenting are and what they are hoping to get out of the presentation. Off-topic presentations are usually boring and will not endear you to the audience. Deliver what the audience wants to hear.
- ***Do not try to say too much*** – you risk losing your main message and curtail the valuable question time. Your knowledge of the subject is best expressed through a clear and concise presentation that is provocative and leads to a dialog during the question-and-answer session when the audience becomes active participants. If you do not get any questions, your presentation was either incomprehensible or trite. A side effect of too much material is that you talk too quickly, another ingredient of a lost message.
- ***Be logical.*** Think of the presentation as a story. There is a logical flow—a clear beginning, middle, and an end. You set the stage (beginning), you tell the story (middle), and you have a big finish (the end) where the key points of your message are clearly understood. Later in this section the structure of a presentation will be given in more detail.

- ***Practice and time your presentation***. This is particularly important for inexperienced presenters. It is common to deviate, and even worse to start presenting material that you know less about than the audience does. The more presentations you give, the better you are going to get. An important talk should not be given for the first time to an audience of peers. You had better deliver it to your research collaborators who will be kinder and gentler but still point out obvious discrepancies. Laboratory group meetings are a fine forum for this.
- ***Use visuals effectively***. Presenters have different styles of presenting. Some can captivate the audience with no visuals; others require visual cues and in addition, depending on the material, may not be able to present a particular topic well without the appropriate visuals such as graphs and charts. It is a useful rule of thumb to have no more than one visual for each minute you are talking, otherwise you may run over time. Avoid reading the visual unless you wish to emphasize the point explicitly, the audience can read, too! The visual should support what you are saying either for emphasis or with data to prove the verbal point. Finally, do not overload the visual. Make the points few and clear.
- ***Review audio or video of your presentations***. There is nothing more effective than listening to and viewing a presentation you have made. Your mistakes and faults will become obvious. Seeing what is wrong you will be more likely to correct it the next time. You need to work hard on breaking bad habits; it is important.
- ***Provide appropriate acknowledgements***. People ought to be acknowledged for their contributions. Too many gratuitous acknowledgements, however, degrade the people who actually contributed, besides, you will run out of time. It is often appropriate to acknowledge people at the beginning or at the point of their contribution so that their contributions are very clear.

Presentation structure

When preparing a presentation you should always remember that oral communication is different from written one. Listeners have only one chance to hear your talk and can't "re-read" when they are confused. That is why your presentation should be organised around two principles: "***keep it stupid simple***" **(*KISS*)** and "***tell them what you are going to tell them, tell them, tell them what you have told them***". The first principle tells us that presentations overloaded with difficult language and complicated grammatical structures are ineffective. If we follow the second one, the listeners will be likely to remember our key points after the presentation which means that our take-home message will be successfully delivered.

Basically, your conference presentation will follow a structure similar to that of a research paper:

1) Clear and informative **Title.** Remember: complex titles may baffle your audience.
2) **Outline**. Familiarise your audience with a brief plan of your speech.
3) **Introduction**. This includes your hypothesis and objectives as well as a rationale for your study.
4) **Materials and Methods**. Here you should explain why you chose your experimental design and statistical analyses. Present your experiment as a logical, step-by-step process. Do not forget to support your methods by literature and scientific principles.
5) **Results and Discussion**. It is important to relate your results to objectives. The number of data points should be limited and presented clearly.
6) **Conclusions**. In this part of your presentation you will reiterate the main points you want the audience to remember (take-home message). In your visuals show the list of conclusions and their relation to the objectives. Give examples of your findings application. Summarise everything in the end.

It is important to present your subject matter in an organized and logical way. However, your success equally depends on how you present yourself. Here are some practical tips that might help you succeed:

1) Mind your **body language**. Remember, people do tent to judge others by their appearance, so dress appropriately, stand straight, lift your head, control awkward mannerism, make your voice audible and clear, vary your intonation to make your speech lively.
2) **Deal with the audience** appropriately. Keep eye contact with your audience – it is essential for maintaining a good rapport. You will also be able to pick up signals of boredom or disinterest, in which case you can cut your presentation short.
3) **Cope with nerves**. Most people are nervous at the beginning of a presentation. Try not to speak too fast during the first couple of minutes – this is the time when rapport with the audience is established. It might be helpful to memorise your introduction. With practice nerves will make better performance.

PRACTICE

1) *"Signalling devices" are words and phrases that give your audience clear signals as to the direction your presentation is taking. For example, they indicate when you have completed one point in your section and are moving on to the next. In the following exercise, write suitable headings for the groups of phrases to summarise what each of them is signalling. The first heading has been provided as an example.*

1. Introducing and outlining the presentation	**6**.
• The purpose of my presentation today is to… • In today's presentation I'd like to show you … / explain to you how… • In today's presentation I'm hoping to give you an overview of… • In today's presentation I'm planning to look at … / explain … • In today's presentation I'd like to cover three points: firstly … , secondly … , and finally…	• I'll come back to that question later, if I may. • I'll come back to that question later in my presentation. • I'll / We'll look at that point in more detail later on. • Perhaps we can look at that point in the end / a little later. • If anyone has any questions, I'll be pleased to answer them. • I'll do my best to answer all your questions. • Please feel free to ask any question you have.
2.	**7.**
• To begin with, … • To start with, … • Let's start by looking at… • I'd like to start by looking at…	• For example, … • A good example of this is… • To illustrate this point…
3.	**8.**
• So, that concludes [title of the section] … • So, that's an overview of … • I think that just about covers… • That's all I have to say about … • So much for …	• Where does that take us? • Let's look at this in more detail. • What does that mean to us? • Translated into real terms, … • As we can see here…
4.	**9.**
• Now, let's move on to… • Now, let's take a look at… • Now I'd like to move on to… • Next I'd like to take a look at… • Moving on to the next part … / section, I'd like to … • Let me turn now to…	• Well, that brings us to the end of the final section. Now, I'd like to summarise by … • That brings us to the end of the final section. / That concludes my presentation. Now, if I can just summarise the main points again. • That's an overview of … . Now, just to summarise, let's quickly look at the main points again.
5.	**10.**
• As I mentioned earlier, … • As we saw earlier, … • You may recall that we said … • You may recall that I explained …	• Thank you for your attention. • That brings the presentation to an end. • That brings us to the end of my presentation. • Finally, I'd like to finish by thanking you (all) for your attention. • Finally, I'd like to end by thanking you (all) for coming today. • I'd like to thank you (all) for your attention and interest.

2) *Work in groups of 3 or 4. Remember the worst presentation you have ever witnessed. Think what made it so bad? Discuss what the presenter should have done to make it more successful?*

3) *What do you worry might go wrong when you make your conference presentation? Write down possible scenarios and discuss them in groups. Suggest ways of mitigating the situation.*

4) *If you have conducted scientific research in the sphere of your specialization and obtained results of your experiment, prepare a presentation about it and deliver it in class. If you have not participated in research work, use a recent paper in your major discipline and present it to your class. Discuss each other's presentations and evaluate them using the sample peer review sheet for conference presentations* *(Appendix 3, p. 206)*

RESEARCH AND GRANT PROPOSALS

Preparing a research or grant proposal is one of the most difficult kinds of writing assignments students encounter at college. In most universities research proposals are a typical requirement for first-year master's students. Having to prepare this proposal is part of graduate training. It is an opportunity to organize your thoughts about your research topic, to decide how you will pursue the work, and to spell out what resources (financial, material, and technical) you need to carry out the research. The writing of a project proposal is an exercise that you will repeat many times in your professional career. The ability to "sell" a project convincingly is a crucial part of your toolbox of skills. You may also consider the thesis or grant proposal as a way of raising your voice to speak out within the academic community.

The proposal for a thesis or dissertation is essentially an outline of the research – like an architectural blueprint for building a house. The clearer the plan, the more timely and successful will be the completion of the house. And the clearer the plan, the more likely it is that it will be approved by your advisor or dissertation committee, with a high probability that the final paper will also be accepted. A well-done, acceptable proposal, therefore, is a kind of personal contract between the candidate, and the committee.

The purpose of the proposal is to ensure that the candidates have done sufficient preliminary reading/ research in the area of their interest that they have thought about the issues involved and are able to provide more than a broad description of the topic which they are planning to research. The proposal is supposed to clearly and concisely answer the questions WHAT, WHY, and HOW, i.e. explain the purpose of the research and how the objectives will be accomplished. The challenge for you as a candidate is to convince members of the scientific community that you a) have identified a scientific problem, b) have a theoretical background and a methodical approach to solve the problem within a realistic time frame and at reasonable expenses, c) with your research you will add a new aspect to the scientific discourse.

Developing a research proposal takes time. The process starts by identifying a general area of research and then developing a focused research question to be answered. Next a research protocol is created. The protocol needs to be appropriate to the research question, but also feasible in terms of time, resources and ethical considerations. The research proposal is the formal description of this process. The first part of the proposal will include the research question to be answered along with a statement of why the area of research is important and what is known already. The second part of the proposal is the methods section, where the plan for answering the research question is given.

When you are ready to start writing the research proposal, the first step is to carefully read over the guidelines of whatever agency you are submitting it to or consult your advisor concerning the deadlines for submission and instructions for the length, structure and format of the proposal. Members of the selection committee usually have to read a large number of research proposals, so good construction and legibility of your proposal will be to your advantage. Besides, proposals that are late or do not meet the requirements are often returned without being reviewed.

There is no one formula for a thesis proposal, given the range of disciplines and organizational sequences for processing it. Every school as well as every funding agency expects that submitted proposals be formatted in a very specific way. These guidelines are strictly enforced, therefore, be sure to follow them exactly. A typical master's thesis proposal form in sciences will include the following sections:

- Title/ Title page
- Abstract or Summary
- Hypotheses and Aims
- Background and Significance
- Preliminary Results (your preparation history)
- Detailed Aims (research design and methods including a tentative timetable)
- Anticipated Results
- References
- Appendices

Now we shall discuss these sections in more detail.

If **Title page** is required, it usually includes the title itself as well as information about the author (name, academic title, position, address, contact information), supervisor(s)' name(s), the university department where the research is supposed to be done and, if applicable, information about other collaborators. Words in the **Title** of your planned thesis should be chosen with great care, and their association with one another must be carefully considered. While the title should be brief, it should be accurate, descriptive and comprehensive, clearly indicating the subject of the investigation. Also, it should contain enough information so that a potential reader can get the main point of the proposal. Compare the titles below. Explain why the first one is more effective than others.

Effect of Antibody to ß-amyloid on the Microglial Mediated Aß-induced Neurotoxicity
Imports Assist Entry into the Nucleus
How Proteins Enter the Nucleus

In the **Abstract or Summary**, key elements of the paper are mentioned. It serves as a proposal "advertisement;" which means it must be simple, interesting and accurate. In the abstract, you should:

- provide context for your proposal;
- introduce the model system you will be using, and why it was chosen to answer the questions proposed;
- state your hypothesis;
- outline your aims and briefly describe the experimental methods to be used and expected results of each aim;
- explain the relevance of accomplishing the proposed research and how it fits within the larger picture. In other words, how will your research affect other areas?

A good abstract reflects the entire proposal. It should be able to stand on its own without reference to the rest of the research proposal. Typically, the word-limit for this section is around 250 words.

Hypotheses and Aims. It is a good idea to introduce the reader to your hypotheses and aims as early as possible. This section should be brief (one-half to one page long). Funding agencies are increasingly requiring that proposals be hypothesis-driven. Even if what you are proposing to do is more of an exploratory nature, you should frame it within the context of a testable hypothesis. Your hypothesis should guide the research.

Aims or goals of the research are also included in this section. The aims should each have a brief description (1 or 2 sentences) of the methodology you propose to apply and how the results will be used to test the hypothesis. The number of aims is usually dependent on the amount of time needed to complete the entire project. Short proposals (i.e., summer research) should have one or two aims. Longer proposals (1–3 years) can have up to 3–4 aims. All aims should be related to the hypothesis, and they also have to be attainable and within your expertise level.

Below you can see two examples of hypotheses. Decide which one is effective and which is not. Explain why you think so.

> I propose to use molecular systematics to test the hypothesis that two species of the Pan troglodytes clade (P.t. troglodytes and P.t.verus) are able to interbreed successfully.
>
> I propose to study the genetic and environmental determinants for key pathways of folate metabolism during human development.

Background and Significance. This section provides context for the research by giving background information on the questions being addressed. This section requires a good and succinct literature review. Include appropriate citations and all relevant information. You should state the rationale behind your proposal and why it is important to answer your specific question. The length of this section varies. If you do not have preliminary results of your own, highlight any research done by others that supports the rationale of your proposal.

Preliminary Results. When available, include work you may have done that is relevant to the project. Attach copies of your own publications that might be seen in connection with your current research. The purpose of this section is to support the feasibility of the proposed project.

Detailed Aims. Include here the specific methods you will use to accomplish your aims. Describe the experiments you will need to carry out to accomplish your proposed goals or aims. Also describe the logic and design behind each experiment proposed. You should include enough detailed information for the reader to understand the methodology, but do not give excessive information (i.e., materials used). Below you can see a very concise example of a Detailed Aim.

> I propose to use both nuclear and mitochondria DNA to analyze polymorphisms characteristic to each group. This will be done using hair samples from P.t. verus and P.t. troglodytes from wild populations.

Alternative methods should be included for experimental approaches that may appear risky (have not been previously used). It is particularly important to provide alternative methods when the outcome of any aim is a prerequisite to others. The description of the alternative approach should not shadow the initial method proposed. Instead, it should be included as a concise description that strengthens the viability of the project.

Timetable. Develop a time table (if possible in table form), indicating the sequence of research phases and the time that you will probably need for each phase. Take into account that at this stage, it can only be estimated, but make clear that you have an idea about the time span that will be needed for each step.

Anticipated Results. Under this heading, you should consider all of the possible outcomes of your study, not just those you expect. In other words, you should consider all the outcomes that you are able to anticipate. The point of this exercise is to think through the design of your experiment. Will your experiment give outcomes that are interpretable? How likely is each of the outcomes? For each possible result, you should discuss how you would interpret it and how it would allow you to discriminate among your hypotheses. Will you be able to meet the goals you set out in your Introduction?

In addition, you should consider how your anticipated findings would change the way we think about the topic and how they fit in the context of the field. This is also the place where you should address potential shortcomings or limitations of your proposed study. You are also welcome in this section to speculate on the generality of your findings and suggest new or follow-up questions or experiments that might stem from your work.

References. Provide a reference for each in-text citation. Be sure to follow the suggested format. If not specified, the use of numbered citations is recommended to save space.

Appendices. Any supplemental material, such as photographs or enlarged figures, should be included in the Appendix. Do not use this section to include essential material not included in the proposal because of a page limit. Include tables and figures only if they add to or complement the descriptive text. For example, a figure is sometimes useful to describe a complicated experimental apparatus or model. A table is sometimes helpful if your experiment has many variables or many possible outcomes. Tables and figures are placed in at the end of the document, after the References.

A Note on Grant Proposals

Graduate students are often asked to write grant proposals along with their thesis proposals, and they sometimes find themselves part of teams writing proposals for funding to support their lab activity. Compared to a thesis proposal, a grant proposal typically contains more detail about practical matters such as resources, funding, and timelines. It may be expected to contain a section on how the results of your research will be evaluated (e.g., by practical results). Be as realistic as possible about these matters, remembering, for instance the typical

"50% rule" about funding: if your estimate is more than 50% above the reviewer panel's estimate of likely costs, it may be disqualified. When writing as part of a team, work out individual responsibilities before starting. Take extra care to ensure that all parts of the document are included, correctly formatted, and consistent with each other.

Once you have finished the first draft of your proposal, go through careful editing. The following tips might be useful at this stage.

- Verify that the title, the abstract and the content of your proposal clearly correspond to each other.
- Make sure you keep a reasonable, clear, declarative writing style (use active verbs) throughout the document. Summarize significant issues; make no assumptions where possible.
- Make your proposal reader-friendly. Use bold or italics to highlight important points. Use headers to organize your proposal. Indent paragraphs, and unless absolutely unavoidable, skip a line between paragraphs.
- Make sure your proposal does not contain any grammatical/spelling mistakes or typos; engage a proof reader.
- Request an experienced academic to proofread your proposal in order to ensure the proposal conforms to institutional and international academic standards.
- Before submitting a proposal to a funding agency, get feedback from different mentors. You want to receive feedback in every aspect of the paper, including the science, grammar and organization.

PRACTICE

1) *Formats of research proposals vary across disciplines, schools and proposal types. In Appendix 2, pp. 194-203 you can see two short sample proposals for summer research. Analyse their structure and content. Discuss similarities and differences between the sample proposals and the model for a master's thesis proposal described in this section. Decide which format might suit your present needs. Think how you would organise your content within any of these frameworks.*

THE FULBRIGHT PROGRAM IN UKRAINE

In today's globalized world, international partnerships and exchanges of experience and expertise between scholars from different countries have become an indispensable part of scientific and academic life as well as a necessary prerequisite for one's academic career development. The Fulbright program provides a variety of opportunities for international scholarly cooperation. Established in 1946, it is the oldest and most prestigious international program for exchange of scholars and students funded by the United States government. Today it supports academic exchanges with 155 countries of the world. Funding for the Fulbright Program is designated every year by the U.S. Congress as part of the annual budget.

In Ukraine the Fulbright Program has been working since the beginning of 1992. Its goal was and remains to increase the mutual understanding between people of the United States and Ukraine through scholarly and research exchanges. Since the inception of the Fulbright Program in Ukraine, more than 800 Ukrainian scholars, students, and professionals have travelled to the United States for research or study in U.S. institutions of higher education. During the same period, nearly 500 U.S. scholars, students, and professionals have participated in the Fulbright Program in Ukraine as university lecturers, researchers, and consultants.

There are several types of the Fulbright Program available for students, researchers and academicians in Ukraine. Among the most popular are the following ones:

- **The Fulbright Graduate Student Program** offers grants for Ukrainians who intend to enter graduate degree (Master's, Doctoral) or non-degree programs at U.S. universities. This Program provides an opportunity for graduate students, young professionals, and artists to combine study and independent research in a variety of ways: to pursue a Master's degree for up to 2 academic years; to conduct research outside of a degree program which allows a student to specialize in a particular area; to re-qualify in a different area or to broaden an academic perspective; to participate in a non-degree program of academic study and gain professional experience; to prepare for a qualification exam and entry to a doctorate program; to take advanced courses; to practice teaching through an assistantship in a university.
- **The Fulbright Faculty Development Program (FFDP)** offers a 9–10 month, non-degree, professional development program at a U.S. university. The Fulbright Faculty Development Program targets teaching faculty and scholars under the age of 40 who are either teaching at institutions of higher learning or are affiliated with academic, research, or cultural institutions, including libraries and museums, or with NGOs (Non-Governmental Organizations). FFDP is designed for those, who have not received a post-graduate academic degree or who have received their degree within the past 5 years.
- **The Fulbright Scholar Program** offers research opportunities at the U.S. universities and research institutions for scholars, researchers and other professionals for a period from 3 to 9 months. The Fulbright Scholar

Program targets scholars and teaching faculty, who are either teaching at higher education institutions or are affiliated with academic, research, or cultural institutions, including libraries, archives and museums, or with NGOs. Fulbright Scholar Program is designed for those, who have received a post-graduate academic degree or who will receive their degree before the grant's beginning and for researchers who have equivalent experience not less than 5 years.

To be successfully selected for participation in any of these programs one is supposed to comply with a number of requirements. Among other things candidates should submit two academic pieces of writing: **A Project Statement** and **A Personal Essay**. The former is the written description of the candidate's proposed activity in the U.S. Its purpose is to allow the candidate to answer the question "*What can I contribute to the knowledge base in my area of specialization or to bringing about positive change in education?*" The latter gives candidates an opportunity to introduce themselves and to answer the questions "*Who am I?*" and "*Why will I achieve my study or research objectives?*" This exercise requires taking a serious look at oneself, at one's strengths and weaknesses, and at personal goals and ambitions.

In case you are applying for The Fulbright Graduate Student Program your "Project Statement" might be referred to as your "Study Objectives". Below you can see guidelines for writing both "Study Objectives" and "A Personal Statement" as they appear on the official website of The Fulbright Program in Ukraine. Read them attentively and discuss with your peer students.

Graduate Student Program

Study objectives

Your goal in the essay that follows is to limit yourself, as much as possible, to talking about what you would like to do when you are in the United States. Focus your study plan on the program of study and on the nature of the course work you want to take. Your prospectus below should be as detailed as possible, because your preparation, in this regard understanding what your project entails, is the most convincing evidence that you will be able to complete the project.

Those issues of your personal accomplishments that you feel might also clearly demonstrate this will be addressed in other parts of the application, and do not need to be repeated here.

It is best to write this essay on either a three or four paragraph form. Below is my sense of the best way to write it in four paragraphs.

This essay will likely be the most important part of your application; it is worth taking a long time to write, and to try many different drafts before you are satisfied with it. Like your narrative vita, if it is possible, ask for help from older scholars, as they may see links and facets of your project that otherwise you might have missed.

Paragraph one: Here, in a short but detailed paragraph, spell out what scholarly work you would like to accomplish in the United States. The first sentence should read something like "I wish to study in the United States so that I might (complete whatever your project is)" It is not enough to say that you would like to receive a master's degree; a master's degree will require that you write a thesis, and this paragraph should tell, as clearly as you can imagine, what such a thesis would be about. Spell out your project, and locate it in the realm of your field; talk, if you can, briefly, about in what way your thesis will benefit your field, and the way in which you intend to undertake it. But keep these comments brief, as you will have a chance to return to them later. This first paragraph is all about you, and your project, and will demonstrate how well you understand it.

Paragraph two: Here, talk in as detailed a fashion as you can, about why this project needs to be undertaken in the States, and cannot be just as easily completed at home. Though your inclination might be to talk about how and why you cannot complete your project at home, it is better to make this claim through contrast, telling what resources and opportunities you feel might be available to you in the States. Again, if you can, talk not only about infrastructure issues (research libraries, for example), but what, if any, impact being in a foreign culture might have, and how it will positively impact your work.

Paragraph three: Here, bring together the two above, and show the way general trends in the United States have very particular products in the States that might help your work. If you know of theorists, scholars, or scientists who are doing work there which is not being pursued here in Ukraine, then this is the place where you should mention them. Also, here is a place to talk about how being part of an American University might help you complete your work more readily than if you were to stay in Ukraine.

It is important to note in paragraphs two and three that you are asked to not request that you be placed at a particular University. This, though, does not prevent you from making your preference known, in terms of people whose work you admire, and who you might like to work with; though this is unlikely to guarantee you will work with these people, it does go a long way to showing that you know your project, and are aware of the ways in which study in the United States might help to advance it.

Paragraph four: Here, in your conclusion, talk about the project you introduced in the first paragraph. But where in that introductory paragraph, you spoke of it on a theoretical level, here talk about it on a practical level. What will your project look like when it is finished (a book, a study, something else altogether), and why is it reasonable to think that you will finish it in the time allotted to you. Here, more than anywhere else, express why you think you are the person to complete this task, and tell us briefly why your project will benefit both the larger field of your study, and Ukraine, when it is completed.

Retrieved from http://www.fulbright.org.ua/uploaded/Programs%20 materials% 202013/ Student_Study%20Objectives.doc

Personal Statement

This is to serve as a record of all the things you have done that would qualify you for a Fulbright fellowship, and at the same time it should include some slight mention of how studying in the States will help you achieve your professional and scholarly goals.

This is NOT a traditional vita, a list of your accomplishments and educational background, but instead it is to be arranged in the form of an essay.

As with the statement of purpose, this might be best written on a four paragraph model.

Paragraph one: Present your educational objectives in clear, concise, theoretical terms: spell out, as clearly and specifically as you can, the way you understand your larger work (your interests overall that have driven you to choose the particular project, as outlined in the statement of purpose), and also the way that you see those interests fit into the larger directives of your field; for example, if your work is with beets you would want to talk specifically about how your interest is to improve the field of agriculture through a study of the particular needs of soils towards the aim of creating those crops which are best suited to their native soils. Or something of that sort; restating the basic goals of your profession is not enough, but you must find your place within that field, and state that as succinctly as possible.

This is probably the most difficult, and in some ways, the most important part of your narrative vita; you can only really begin to answer this question after you have fully worked out your statement of purpose. Do not hesitate to ask those you work with who are senior in your field for help and advice here; They will likely have a richer sense than you of how your project, and your larger interests, will fit into the larger frame of your discipline, and might be able to help you articulate this as clearly as possible.

This is to be a short paragraph, likely no more than three sentences; make them count.

Paragraph two: Talk here, at as much length as you feel comfortable, about how your educational and personal experiences helped you arrive at the particular interests and scholarly objectives you have outlined in the preceding paragraph; this is an easier, more slow based developmental narrative: how did you come to the larger field, what were your initial interests and accomplishments (note here those awards won, papers delivered, and conferences attended, etc, which you think might make you look better in the eyes of the review panel); the idea here is to show your development as a scholar, and to begin to create a story of your professional life to which the Fulbright grant would seem as some sort of culmination, even if only a temporary peak.

Here, and in the paragraph that follows, keep in mind the following advice: create the impression that the Fulbright is inevitable, not a gift, and the readers of your application will tend to agree with you Instead of making it seem like a big leap for you to go and study overseas, make it seem like a natural outcome, and something which the Fulbright Committee can do for you.

This should likely be the longest paragraph in the essay, or at least as long as the one that follows.

Paragraph three: Here, talk specifically about the work you have done up till now in your attempts to complete the work you would like to do in the States. If, as in my example above, you want to study the nutritional needs and benefits of beets, talk about the work you have done with beets. Where in the paragraph above, you talked about your educational and personal life in the larger terms of all your scholarly work, here you should talk about your work on your particular project. Again, any awards or special commendations you have received, any conference papers you have delivered on this topic, anything to show that you have not dreamed up this project only to win a Fulbright, but that it is a passionate and long held professional interest of yours, will be convincing, and should be out here. You will be most convincing if you can make a case that you have exhausted the resources Ukraine offers for completing your task, and suggest how you think studying in the States might offer you new resources to accomplish your professional goals.

In short, this paragraph should be the story of your strong and committed start to a project that is right now frustrated due to the lack of opportunities available to you. Close with a suggestion, again as specific as you can, of the ways in which you think studying in the United States might help you to complete your work.

This might be the second longest paragraph of the essay; think of it as the background to your statement of purpose, and its companion: the story of why you want to do the work you want to do.

Paragraph four: This will be your conclusion, and in it, you should look, briefly, to the future: what the Fulbright Selection Committee wants to hear is the way that your completed project, and the experiences you had studying in the United States, will advance more generally your field and the level of scholarship in Ukraine. Look back towards your first paragraph, and reflect here, briefly, the way your project might influence the larger field in which you work. Talk a little about how you can improve professional life and scholarly work in Ukraine. This paragraph should also be short, like the twin of your introductory paragraph, to which it is most closely related.

Retrieved from http://www.fulbright.org.ua/uploaded/Programs%20 materials 202013/Student_Personal%20Statement.doc

PRACTICE

1) *Below you can see two students' personal statement essays: one for a graduate program in social sciences and the other for a post-graduate program in biology. Read and compare them. Do you think they are written in the appropriate style? Are persuasive? Need any improvement? Discuss these questions in class.*

Personal Statement Essay 1

The rapidly growing elderly population is becoming a serious social problem in many countries. Some countries have been successful at finding solutions for this problem but others have not. Japan is one of the latter countries. Although Japan has one of the highest life expectancy rates and a reputation for good quality of life for its elderly population, it has been unsuccessful at addressing this problem. Compared to other industrialized countries, Japan lags behind in programs for elders who are physically disabled, bedridden or in need of long term care. The current economic crisis is exacerbating this situation as the government is cutting funding for elder programs. This problem resonates deeply with me, and I hope to someday work on finding a solution. It is for this reason that I am applying to the graduate program in social work at Boston University: I seek the skills and knowledge I need to return to Japan and work for a social work service.

My interest in the elderly dates back to my childhood. Growing up with my grandparents greatly influenced my values and personality: they taught me to be self-motivated and disciplined. Their resilience and support has helped me to persevere even when confronted with seemingly insurmountable obstacles. Because of their kindness toward me I have a deep respect for them and for elderly people in general. This is what motivates me to become involved in the field of social work.

Traditionally in Japanese society, the care of one's parents is believed to be the children's duty. After World War II, such traditions have evolved due to changes in family structure. No longer is the eldest child the only one to inherit his parent's property, and two-income families have become the norm. These changes have left Japanese people at a loss as to how to care for their aging parents. The current response to this problem seems to be hospitalization.

Families increasingly hospitalize their elders who are physically disabled, bedridden or in need of long-term care. These individuals are usually transferred to nursing homes, but because of sparse accommodations and a one to two year wait list, they end up staying with family members who are often ill equipped to care for them. As a result, there are a number of incidences of elder abuse by family members and elder suicide. Also, there are many other elderly people who live alone – every year, many of them die with no one, not even their family members, having knowledge of their death.

Currently there is no social welfare program in Japan that offers assistance to these elders and their families. In the light of these terrible problems, the need for such a program is obvious. My interest in social work is to find ways to develop and improve the types of services available to the elderly in Japan at a systematic level. I want to be involved in the organizing, managing, developing, shaping and planning of social policies related to the elderly. I believe the social work program at Boston University will allow me to do that. By studying macro social work at Boston University, I will learn about established social systems, assessment and intervention strategies. In addition, Boston University's emphasis on urban issues appeals to me immensely. As I will be returning to work in Osaka, the second largest city in Japan, graduate work in this area will better equip me for the challenges I will be facing. To me, an urban mission is a commitment to identify and find solutions to issues faced by urban areas.

I believe I am well prepared for graduate work. During my undergraduate study, I acquired the necessary background knowledge by taking advanced courses in the areas of psychology and sociology, including sociological research methods, social theory, statistics, psychological research, and psychotherapy. Along with these courses, I had an internship at the Asian Task Force Against Domestic Violence, a non-profit organization. I also volunteered at Sawayaka-en, a nursing service, and Asunaro Children's Mental Hospital in Japan. From this internship and my volunteer work, I have gained practical experience which I feel will contribute to my academic and professional success.

I expect the graduate work at Boston University to be demanding, challenging, and ultimately rewarding. I look forward to the experience from an intellectual as well as social point of view – I hope to learn and grow as an individual and a macro social worker. I hope that I will be allowed to do so at Boston University.

Personal Statement Essay 2

As a child growing up in Bronx, New York, I knew my tenacity would help me realize my goals in life. I vividly remember learning of the life story of Dr. Mae C. Jemison, shortly after she became the first African-American woman to travel in space in 1992. As I read of her extraordinary rise from humble beginnings, I was filled with the determination that would carry me through the obstacles and challenges of my life. My proclivity to the sciences also began early in my life. I would pour over my Mother's medical dictionary in attempts to comprehend the disease that had incapacitated her during my early childhood, Multiple Sclerosis. Since that time, I have maintained an admiration of the extraordinary possibilities available through research.

I earned a Master of Science in Biomedical Writing from XX in 2010. Through my studies of medical writing, I have become an effective communicator of scientific concepts. During this time, I explored my inclination for medical writing through exercises in regulatory and non-regulatory documents, including working as a writer and editor for a peer-reviewed journal, XX. While my studies at XX afforded me a tremendous learning experience, I have yet to satiate my yearning for scientific research.

I first experienced the laboratory after accepting an offer of a full academic scholarship from XX College. As I performed coursework of dissections, cultures, and assays, I felt confident that I had begun to explore what would be my life's work. I was energized, and my hard work was rewarded with recognition on the Dean's List.

After I graduated from XX College in 2005, I accepted a position as a Biology and Chemistry Teacher for XX, a non-profit organization based in Harlem, New York City for high school students. I constructed the biology and chemistry curriculum for the science program, which included lectures and laboratory lessons. In this position, I offered my students exposure to enriching experiences that were structured to give them an academic advantage. As I built relationships with my students and witnessed their growth as budding scientists, I discovered a love for teaching science.

In 2007, I was employed at YY, a company that contracts the manufacturing of GLP/GMP products and medical devices, conducts research and development, and performs testing and services for custom biopharmaceuticals and cellular therapeutics. I worked as a Document Specialist, writing the preclinical and research study reports for the various laboratories at the facility including embryology, virology, and stem cell therapeutics.

Subsequently, in 2008, I began my current position as a Scientist for ZZ consumer healthcare products. In this position, I assess the safety of marketed pharmaceutical products by analyzing information from various sources, such as literature, regulatory, clinical, and marketing contacts. In addition, I write aggregate regulatory reports on my findings on products used in various therapeutic areas, including psychiatric, immunology, and oncology.

At this point in my life, I am ready to take my talents and capabilities to the next level, and fulfil my potential by initiating a career in cancer research. Cancer is a great mystery of the biomedical community, which dates back to 1500 BC. As a scientist, I feel fortunate to live in a time where cures and vaccinations are on the horizon for a vast number of cancers. I want to be a part of the ongoing journey to develop improved treatments and preventative measures against this disease. Like many, I have lost loved ones to cancer, which further fuels my determination to succeed in this field.

After reading The Immortal Life of Henrietta Lacks (HeLa) in 2010, I became even more inspired by, and grateful to all those who had sacrificed for the evolution of cancer research. I believe Ms. Lacks' story is symbolic of the extent of sacrifice necessary to attain extraordinary goals. I look forward to devoting my life to researching and teaching toward the inevitable solutions of cancer. As I have witnessed the life-changing results of pharmaceutical products in patients like my mother, I appreciate the role of drug development in human life.

A PhD will allow me to achieve the necessary understanding of the academic details involved with research, and solidify my future as a cancer research scientist. With its diverse research endeavors and commitment to improve various facets of human life, the Biology Department at NN is an ideal place for me to develop my analytical and research capabilities. I am particularly interested in the ongoing research in Dr. AA laboratory. This area of study is fascinating as well as underappreciated in oncology therapeutics. My desire is to be at the forefront of cancer research, and I believe PhD research under Dr. AA will help me achieve my goals. The excellent research facilities and distinguished faculty members of your university provide an intellectually stimulating and culturally diverse atmosphere, which I believe will help me in expanding my scientific outlook.

2) *Go to the official website of* ***The Fulbright Program in Ukraine http://www.fulbright.org.ua/en/*** *and find a program you might be eligible for. Study the candidate requirements for the program. Use the guidelines in this course book and any additional information you get from* ***The Fulbright Program*** *website to write a draft statement for the project you might be interested to carry out as an international exchange student.*

APPENDIX 1

READING BANK

VALUES IN SCIENCE: AN EDUCATIONAL PERSPECTIVE

Douglas Allchin, University of Texas

ABSTRACT. Science is not value-free, nor does it provide the only model for objectivity. Epistemic values guide the pursuit and methods of science. Cultural values, however, inevitably enter through individual practitioners. Still the social structure of science embodies a critical system of checks and balances, and it is strengthened by a diversity of values, not fewer. Science also exports values to the broader culture, both posing new values-questions based on new discoveries, and providing a misleading model for rational decision-making. Science teachers who understand the multi-faceted relationships between science and values can guide students more effectively in fully appreciating the nature of science through reflexive exercises and case studies.

1. Introduction

A fundamental feature of science, as conceived by most scientists, is that it deals with facts, not values. Further, science is objective, while values are not. These benchmarks can offer great comfort to scientists, who often see themselves as working in the privileged domain of certain and permanent knowledge. Such views of science are also closely allied in the public sphere with the authority of scientists and the powerful imprimatur of evidence as "scientific". Recently, however, sociologists of science, among others, have challenged the notion of science as value-free and thereby raised questions – especially important for emerging scientists – about the authority of science and its methods.

The popular conceptions – both that science is value-free and that objectivity is best exemplified by scientific fact – are overstated and misleading. This does not oblige us, however, to abandon science or objectivity, or to embrace an uneasy relativism. First, science does express a wealth of *epistemic values* and inevitably incorporates *cultural values* in practice. But this need not be a threat: some values in science govern how we regulate the potentially biasing effect of other values in producing reliable knowledge. Indeed, a diversity of values promotes more robust knowledge where they intersect. Second, values can be equally objective when they require communal justification and must thereby be based on generally accepted principles. In what follows, I survey broadly the relation of science and values, sample important recent findings in the history, philosophy and sociology of science, and suggest generally how to address these issues.

2. Values in Science and Research Ethics

The common characterization of science as value-free or value-neutral can be misleading. Scientists strongly disvalue fraud, error and "pseudoscience", for example.

At the same time, scientists typically value reliability, testability, accuracy, precision, generality, simplicity of concepts and heuristic power. Scientists also value novelty, exemplified in the professional credit given for significant new discoveries (prestige among peers, eponymous laws, Nobel Prizes, etc.). The pursuit of science as an activity is itself an implicit endorsement of the value of developing knowledge of the material world. While few would tend to disagree with these aims, they can become important in the context of costs and alternative values. Space science, the human genome initiative, dissection of subatomic matter through large particular accelerators or even better understanding of AIDS, for instance, do not come free. Especially where science is publicly funded, the values of scientific knowledge may well be considered in the context of the values of other social projects.

From the ultimate values of science, more proximate or mediating values may follow. For example, sociologist Robert Merton (1973) articulated several norms or “institutional imperatives” that contribute to “the growth of certified public knowledge” (see also Ziman 1967). To the degree that public knowledge should be objective, he claimed, scientists should value “pre-established apersonal criteria” of assessment. Race, nationality, religion, class, or other personal or social attributes of the researcher should not matter to the validity of conclusions - an ethos Merton labelled ‘universalism’. Merton’s other institutional norms or values include organized scepticism, disinterestedness (beliefs not biased by authority - achieved through accountability to expert peers), and communism (open communication and common ownership of knowledge). As Merton himself noted, these norms do not always prevail. Still, they specify foundational conditions or proximate values that contribute to the development and certification of knowledge in a community (more below). Specific social structures (such as certain reward systems or publication protocols) that support these norms thus form the basis for yet another level of mediating values.

Other proximate or mediating values that promote the ultimate goal of reliable knowledge involve methods of evaluating knowledge claims. These *epistemic* values include controlled observation, interventive experiments, confirmation of predictions, repeatability and, frequently, statistical analysis. These values are partly contingent. That is, they are derived historically from our experience in research. We currently tend to discount (disvalue) the results of any drug trial that does not use a double blind experimental design. But such was not always the case. The procedure resulted from understanding retrospectively the biases potentially introduced both by the patient (via the placebo effect) and by the doctor (via observer effects). Each is now a known factor that has to be controlled. The elements of process (both methods of evaluation and institutional norms), of course, are central to teaching science as a process.

While the pursuit of scientific knowledge implies a certain set of characteristically “scientific” values, the relevance of other values in the practice of science are not thereby eclipsed. Honesty is as important in science as elsewhere, and researchers are expected to report authentic results and not withhold relevant information. Ethics also demands proper treatment of animals and humans, regardless of whether they are subjects of research or not (Orlans 1993). Science is not exempt from ethics or other social values. Knowledge obtained by Nazi researchers on hypothermia and the physiological effects of phosgene, for example, may pass tests of reliability, but the suffering inflicted on the human subjects was unwarranted (Caplan 1992; Proctor 1991). Hence, we may still debate whether it is appropriate to use such knowledge (Sheldon et al. 1989). Similar questions might be asked about U.S. military studies on the effects of radiation on humans. Again, social values or research ethics are not always followed in science (see, e.g., Broad and Wade 1982), but they remain important values. The disparity between the ideal and the actual merely poses challenges for creating a way to achieve these valued ends – say, through a system of checks and balances. Protocols for reviewing research proposals on human subjects, for monitoring the use and care of laboratory animals, or for investigating and punishing fraud each represent efforts to protect wider social values in science.

The topics or ends of research, as much as the methods or practice of science, are also the province of ethical concern and social values. Weapons research, even if conducted according to Merton's norms and its results evaluated using scientific standards, is not ethically idle or value-neutral. Nor is research into better agricultural methods aimed to alleviate hunger or low-cost forms of harnessing solar or wind energy in poor rural areas. In each of these cases, the researcher is an ethical agent responsible for the consequences of his or her actions, good or bad. Again, appeal to science is no escape from ethics. Where the consequences are clear, the frequent distinction in science between "pure" and "applied" research is not ethically significant. Many conservation biologists, for example, are well aware of the values inherent in their "basic" research and sometimes shape and deploy the content of their science in a politically self-conscious way (Takacs 1996). Where debates about research arise – say, about transplanting fetal tissue or gene therapy – there are real conflicts about social values; the question of the ultimate value or ethics of research in these areas can neither be resolved by science alone nor disregarded by scientists in these fields as irrelevant.

3. Values Entering Science

Science proceeds through the agency of individuals and – not unexpectedly, perhaps – individual scientists express the values of their cultures and particular lives when they engage in scientific activity. For example, in cultures where women or minorities have been largely excluded from professional activity, they have generally been excluded from science as well. Where they have participated in science, they have often been omitted from later histories (e.g., Rossiter 1982; Kass-Simon and Farnes 1990; Manning, forthcoming). The line demarcating science and society can be fuzzy in practice.

More deeply, however, the conclusions of science at many times and in many places have been strongly biased, reflecting the values of its practitioners (in striking contrast to Merton's *norm* of universalism). For example, late 19th-century notions of the evolution of humans developed by Europeans claimed that the skulls and posture of European races were more developed than 'Negroes' (Gould 1981). In a progressive view of evolution (adopted even by Darwin himself), persons of African descent were deemed inferior intermediaries on an evolutionary scale – as "proven" by science. When theories about evolution changed to suggest that "less-developed" or neotonous (more childlike) skulls were "more progressive", conclusions from the same data reversed, preserving "scientifically" the superior status of the scientists' race (Gould 1977). Facts were shaped to fit preexisting judgments and values about race. Likewise, female skulls, skeletal anatomy and physiology were taken by male scientists as evidence of women's "natural" role in society. The "scientific" conclusions, which reflected the values of the men, were taken to legitimate social relations that continued to privilege males (Fee 1979; Schiebinger 1990; Smith-Rosenberg and Rosenberg 1973). Perhaps such values should not enter science, but they do.

Values about race and sex, however, have not been the only values to shape science. The phrenology debates in Edinburgh in the early 19th century followed instead class differences (Shapin 1979). Today, notions about biological determinism, especially about the role of genes in governing specific behaviours, follow similar patterns, where some persons appeal to science to try to justify economic disparities as products of nature rather than as the exercise of power (Lewontin, Rose and Kamin 1984). By contrast, disagreement between Boyle and Hobbes over the vacuum pump in the late 17th century was guided in part by values about governance and the role of the sovereignty in the state (Shapin and Schaffer 1985). Even natural history museum dioramas of animal groupings designed by researchers have reflected cultural values about nuclear families and patriarchy (Haraway 1989, pp. 26-58). While we may now characterize all these cases as examples of "bad science", they exemplify how values can and do enter science and shape its conclusions. Moreover, one must always bear in mind that in their own historical context, these examples were considered "good" science.

While the role of values in these cases can seem obvious from our perspective, it may not be appropriate for us to interpret the scientists as exercising their values deliberately or consciously. To interpret the entry of values into science in cases such as these, one must focus on individual cognitive processes. That is, one must examine the thought patterns of particular agents rather than either abstractly reconstructed reasoning or the influences of a diffusely defined "culture". Especially valuable is the notion of *cognitive resources*: all the concepts, interpretive frameworks, motivations and values that an individual brings from his or her personal experience to scientific activities (Giere 1988, pp. 213-221, 239-241). Cognitive resources affect how an individual notices certain things, finds some things as especially relevant, asks questions or poses problems, frames hypotheses, designs experiments, interprets results, accepts solutions as adequate or not, etc. As a set of resources or *tools*, a person's cognitive orientation will both make certain observations and interpretations possible while at the same time limiting the opportunity for others (see also Harding 1991). Succinctly, a person's scientific contributions will be shaped by the domain of his or her resources or values.

An individual's cognitive resources will be drawn from his or her culture, limiting what any one person can contribute to science. Further, because each person's biography and intellectual training are unique, cognitive resources will differ from individual to individual, even within the same culture. Hence, one may well expect disagreement or variation in interpretation in any scientific community. Far from being an obstacle to developing consensus, however, the variation of a community can be a valuable resource. That is, only conclusions that are robust across varying interpretations will tend to be widely perpetuated (Wimsatt 1981).

Indeed, variations in cognitive resources can be critical to isolating and correcting error. For example, in the 1860s through 90s anthropologists had developed numerous ways to measure skulls and calculate ratios to describe their shapes. In what Fee (1979) described as "a Baconian orgy of quantification", they developed over 600 instruments and made over 5,000 kinds of measurements. Despite three decades of shifting theories, falsified hypotheses and other unsolved paradoxes, the conclusions of the craniologists – all men – remained the same: women were less intelligent. At the turn of the century, however, two women began work in the field. They showed, among other things, that specific women had larger cranial capacity that even some scientists in the field, and that the margin of error in measurement far exceeded the proposed sex differences – and they strengthened their work with statistical rigor. Here, the women's perspective may have been no less biased or guided by values, but their complementary cognitive resources, with the interests of women, were critical to exposing the deficits in the men's studies. This example illustrates that if science is "self-correcting", it does not do so automatically. Identifying and remedying error takes work - and often requires applying contrasting cognitive resources or values. The possibly paradoxical conclusion is that one should not eliminate personal values from science – if indeed this were possible. Instead, the moral is: "the more values, the better". Contrasting values can work like a system of epistemic checks and balances.

The many cases of bias and error in science have led to more explicit notions of the social component of objectivity. Helen Longino (1990), for example, underscores the need for criticism from alternative perspectives and, equally, for responsibly addressing criticism. She thus postulates a specific structure for achieving Merton's 'organized skepticism' ('2). Sandra Harding (1991) echoes these concerns in emphasizing the need for cognitively diverse scientific communities. We need to deepen our standards, she claims, from "weak objectivity", based merely on notions of evidence, to "strong objectivity", also based on interpreting the evidence robustly. Both thinkers also point to the role of diversity of individuals in establishing relevant questions and in framing problems, thus shaping the direction of research more objectively. In this revised view, science is both objective *and* thoroughly "social" (in the sense of drawing on a community of interacting individuals). Fortunately for science educators, the classroom is an ideal location for modelling this kind of collective activity.

The role of alternative values in exposing error and deepening interpretative objectivity highlights the more positive role of individual values in science. Even religion, sometimes cast as the antipode of science, can be a cognitive resource that contributes positively to the growth of knowledge. For example, James Hutton's theological views about the habitability of the earth prompted his reflections on soil for farming and on food and energy, and led to his observations and conclusions about geological uplift, "deep time", the formation of coal, and what we would call energy flow in an ecosystem (Gould 1987; Allchin 1994). Likewise, assumptions about a Noachian flood shaped William Bucklands's landmark work on fossil assemblages in caves, recognized by the Royal Society's prestigious Copley Medal. Other diluvialists drew attention to the anomalous locations of huge boulders, remote from the bedrock of which they were composed (though they supposed the rocks were moved by turbulent flood waters, we now interpret them as glacial erratics). These discoveries all had origins that cannot be separated from the religious concepts and motivations that made the observations possible. Values entering science from religion – or from virtually any source – can promote good science. As suggested above, however, they sometimes also need to be coupled with mechanisms for balancing then with complementary values.

4. Values Exported from Science

Just as values of a society can enter science, so, too, can values from the scientific enterprise percolate through society. The most dramatic redistribution of values may be the values of science itself. To the extent that science (and technology) are perceived as successful or powerful, things associated with them can gain authority or value. Commercial advertising, for example, can draw on the images of science to promote certain products as expressions of "scientific" research or as superior to competing products. The "scientific" nature of the comparison can even dominate over the values on which the comparison itself rests. The conclusions of science themselves are accorded an image of value. One can see the ethical implications where conclusions that themselves draw on social values (such as those regarding race, sex, class, culture, etc.) are given the imprimatur of scientific authority, thereby reinforcing pre-existing distributions of power without justification.

The most dramatic social influence of scientific values, however, may be the image of science itself as a model for all problem-solving. Science (or technology) is sometimes viewed, first, as the panacea for all social problems and, second, as the exclusive or primary means for objectivity, even where other values are involved. Not all problems are amenable to scientific approaches, however, and a narrowly scientific or "technocratic" view can forestall solving problems in the appropriate realm. Garrett Hardin (1968) noted, for example that "the population problem has no technical solution". That is, population pressure is fundamentally an *ethical* challenge about the freedom to bear children in the context of limited global resources. Neither better agricultural efficiency nor reproductive control technology can avert a "tragedy of the commons". Instead, we must reach some consensus about the ethics of an individual's use of common resources and how we may enforce such collective judgments about reproductive rights or privileges.

We often need to integrate scientific values with other ethical and social values. Science can help identify unforeseen consequences or causal relationships where ethical values or principles are relevant. In addition, individuals need reliable knowledge for making informed decisions. One archetypal hybrid project is risk assessment. Scientists can articulate where, how, and to what degree a risk exists, for example. But other values are required to assess whether the risk is "acceptable" or not. Communicating the nature of the risk to non-experts who participate in making decisions can thus become a significant element of science. Where one expects scientists or panels of technical experts to solve the problem of the acceptability of risk, science is accorded value beyond its proper scope – and others abdicate their responsibility in addressing the sometimes more difficult questions of value. Likewise, those who do not address the facts of the matter fail in their responsibility to make an informed decision. Facts and social values function in concert.

As noted above, the values of science may also be applied inappropriately as a model for decision-making. While quantification is often an asset for science, for example, it does not address all the ethically relevant dimensions of technological risk. Cases of risk assessment, in particular, require addressing questions about the distribution of risk among different persons and about the autonomy of accepting risk. Efforts to reduce the problem to a single numerical scale (and then to minimize risk) can obscure the central issues. What matters socially and ethically is the meaning more than the magnitude of the risk (e.g., Sagoff 1992). A "scientific" approach to solving global warming, for example, might easily focus on cost-effective means of reducing greenhouse gas emissions, diverting attention away from the historical sources of the problem and the ethical need for accountability and remedial justice. Cases of uncertainty pose special problems for applying scientific values. Scientists generally refrain from advocating claims that cannot yet be substantiated. Ethically, however, one often wishes to hedge against the possibility of a worst case scenario (major floods, nuclear melt-downs, ozone depletion, etc.) – even if the actual expected consequences are not yet proven. In cases of uncertainty, scientific values about certified knowledge ("assume nothing unproven") and ethical values about communal action ("assume the worst') can diverge (see Shrader-Frechette 1991). One task in teaching is clearly to articulate the limited domain of scientific values and how they integrate with other values.

Controversies over the flouridation of public water supplies exemplify well some of the potential problems and confusions about the role and value of science in social policy (Martin 1991). Both sides of the debate appeal to science as an authority. In each case, however, the science is presented as simple and unproblematic, though complexities and uncertainties exist. In addition, science is treated as the final arbiter, though research indicates that there are *both* benefits (associated with reducing tooth decay) and risks (associated with flourosis and cancer). In this case, the benefits and risks are not commensurable, and no scientific assessment of the ultimate value of flouridation is possible without the expression of further values. In this case, as in others, the scientific value of empirical certainty can be confused with what science can sometimes actually provide. Even technical certainty does not exclude other, non-scientific values from contributing to resolving disputes about public policy.

Finally, scientific knowledge and new technologies can introduce new ethical or social problems, based on pre-existing values. Many medical technologies allow us to express our values in preserving life and health. At the same time, however, they can bring other values into consideration. With the advent of hemodialysis and organ transplants, for example, their limited availability combined with the existing value of fairness in generating a new problem: ensuring fair access to treatment. Subsequently, ethicists developed new solutions for allocating scarce medical resources (e.g., Rescher 1969). Similarly, ecological knowledge – say, about pesticides, heavy metals, toxic chemicals and other pollutants – has educed conventional values about prudence and respect for life in reshaping our values about waste, consumption, modes of production and our relationship to the environment (see, e.g., Des Jardins 1993; Newton and Dillingham 1994). Science does not create these new values. Rather, it introduces novel situations which require us to apply old values in significantly new ways. An awareness that scientific research is typically coupled with new concerns about ethics and values was reflected, for example, in decisions to couple the human genome initiative with funding of research on the humanistic implications of the project.

Some technologies affect values more indirectly. Medical technologies that help sustain life have confounded our traditional definitions of 'life' and 'death' and the values associated with them. New reproductive technologies, likewise, pose challenges for existing concepts of 'parent' and 'family' (Kass 1985); the potential of human cloning forces us to assess more deeply the concept of genetic identity; and the abilities of computers make us rethink concepts of 'intelligence'. All these innovations challenge us to rethink what it means to be human, just as Copernicus, Darwin and Freud did in earlier centuries. Paradoxically, perhaps, in solving some problems, science and technology can introduce new problems about values that they cannot solve. Yet these consequences are a part of a complete consideration of science and its context in society.

5. Teaching Ethics and Values

Many science teachers shy away from addressing values, imagining that they are outside the domain of science or, worse, betray the very core of science. A deeper understanding of science, values, and objectivity (as sketched above), however, supports a mandate for discussing values in the science classroom. This need not seem risky or difficult.

First, the values which guide scientific inquiry may perhaps be best introduced reflexively. That is, in a constructivist setting-where students are engaged in modest scientific activity themselves - they may be asked to reflect on their own process. What are their standards of proof? How has access to multiple investigators influenced their conclusions? The teacher can create opportunities to articulate and illustrate accepted values (perhaps even simulate an instance of fraud!). But if students are to understand the reasoning that supports the epistemic values, they should be able to question and discuss them, like any scientific claim. For example, inviting students both to give and address criticism among their peers can serve to model methods for developing acceptable claims (see Longino and Harding, above). Students should endeavour themselves to articulate what good process is. They may thereby see scientific values as emerging from the scientists' own goals and experiences.

Alternatively, teachers may introduce scientific values through historical case studies. Historical cases offer the advantage that students can clearly see the consequences of certain values, while also seeing how they function in context (e.g., Hagen, Allchin & Singer 1996). It may also be easier to analyze and discuss methods that are not laden with the students' motivations and sense of self.

These approaches may serve as models for introducing other values and ethics. Teaching ethics and values – like teaching science in a constructivist mode - is not centred on teaching specific content, but rather engaging the students in a process. Students should explore values, with the teacher showing how to discuss them collectively. Learning the questions may thus be more important than learning specific answers. Relevant questions for values or ethical discussions include:

- Who are the stakeholders? What are their interests? Are they involved in the decision-making?
- What are the foreseeable consequences (possibly remote or hidden)? What are the alternatives? Is the worst case scenario acceptable?
- What intentions or motives guide the choice?
- What are the benefits? What are the costs?
- *Who* benefits? *Who* risks or pays the costs? (Who is upstream, choosing benefits? Who is downstream, experiencing the consequences?) Would you be willing to accept any consequence of this action falling on yourself?
- What would be the outcome if everyone acted this way?

Each of these questions helps foster awareness of some aspect supporting the objectivity of values claims. Working from questions (rather than a list of principles) also allows the teacher to situate discussion at different levels of sophistication, unique to each class group. A teacher may recognize that the potential for ethical reasoning develops with age and experience, just as skills for scientific reasoning do. Lessons need to be designed at a level appropriate to the students' educational maturity.

An important goal is for students to learn that *ethics* and discussion of *public values* require justification just as much as any scientific argument does. Teachers need to emphasize especially that sound ethical conclusions are based on general principles – not on an individual's "feelings" or "personal values". Morals must be publicly endorsed. Ethical principles, in turn, are based on careful reasoning, concrete evidence, and *commonly shared* emotions. The willingness to experience the consequences of one's actions and the ability to universalize a decision (noted above) are two common ways to 'test' whether principles are ethical. A good touchstone for justifying an ethical value (as it is in science) is a good critic: reasons must be strong enough and draw on principles general enough to convince someone with an opposing perspective. Ethics, no less than science, aims at objectivity.

Historical cases, again, can be valuable tools for teaching. One can analyze actions in terms of consequences that are known, but that may not have been, obvious to the participants. An essential element, however, is always the active recovery of the context in which actions that may now seem unreasonable were once seen as fully justified (the cognitive interpretive model applies here, as well). To dismiss Nazi research or the Tuskegee syphilis experiment (Jones 1981) as aberrations of a few misguided individuals is to trivialize the deep embeddeness of values in science. One must confront science and values in full context. We must acknowledge that 'blindspots', so obvious in retrospect, are part of the process. Effective ethical inquiry can hopefully make us more aware of potential blindspots, so that we may minimize or reduce them. Other historical cases can help students probe the tensions between context and outcome. The issues of vivisection and the use of animals in research, for example, become sharper when discussed in the context of William Harvey's work on blood flow or Walter Cannon's seminal work on homeostasis (Hagen, Allchin & Singer 1996, pp. 95-103). Students must reconcile the view of common 'textbook knowledge' as value-free with the actual values that were expressed in achieving that knowledge. Engaging in such cases allows students to appreciate the various values that enter and shape the development of scientific knowledge.

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TO COUNT OUR DAYS: THE SCIENTIFIC AND ETHICAL DIMENSIONS OF RADICAL LIFE EXTENSION

David Masci, Pew Research Centre

The prospect of dying has always fascinated, haunted and, ultimately, defined human beings. From the beginnings of civilization, people have contemplated their own mortality - and considered the possibility of immortality. Indeed, many of humanity's oldest and best-known stories, from the Sumerian tale of "Gilgamesh" to the Old Testament Book of Genesis to Homer's "Odyssey," feature mortality and immortality as prominent themes.

Until recently, however, the possibility of dramatically extending human life has been consigned to the realm of speculation or science fiction. Scientists' understanding of why people age - and how to stop aging – was not sophisticated enough to hold out hope that life could be extended much beyond traditional old age. But that may be changing.

Today, scientists at major universities and research institutions are talking about treatments that could extend average life spans by decades - or even longer. None of these medical prospects is yet a reality, and even the most optimistic researchers acknowledge that major breakthroughs could prove elusive. But for the first time in human history, some experts believe we may be at the threshold of a new aging paradigm, one that replaces the generally accepted limits of human life with more open-ended possibilities.

Throughout almost all of human history, life was, to quote 17th-century British philosopher Thomas Hobbes, "nasty, brutish and short." A citizen of the Roman Empire, for example, could expect to live to be about 25. Even in 1900, the average American lived to be just 47, compared with an average of 78.7 years today. One reason average life spans were so short is that many people died in infancy or childhood. Until the advent of modern public health and medicine in the early 19th century, many children died before their fifth birthdays. However, those who survived into adulthood could reasonably expect to live into their 40s, 50s or even 60s. And reaching old age, while relatively rare, was not unheard of. After all, the Bible mentions people living to be "seventy years, or eighty" in Psalms 90:10. And history is full of famous people who lived long, productive lives. For instance, many of the founders of the American Republic - including Thomas Jefferson, John Adams, Benjamin Franklin and James Madison - lived to be at least 80, with Adams dying at 90.

Still, by today's standards, most adults had relatively short lives. Until the advent of antibiotics, countless millions died each year from what today would be easily treatable infections. Poor sanitation often spread diseases such as bubonic plague, cholera and typhus that could decimate populations without regard for age or wealth.

Today, people are continuing to live longer. In fact, every six years, the average life span in the United States increases by another year. According to the 2010 U.S. Census, nearly one-in-seven Americans are 65 or older. By 2050, the bureau estimates, that number will rise to more than one-in-five. Another sign of Americans' increasing longevity is the growing number of people living well into old age. Between 1990 and 2009, the number of centenarians in the U.S. nearly tripled, from 38,300 to 104,099. By the middle of this century, the Census Bureau predicts, more than 400,000 people in the U.S. will be at least 100 years old.

The gradual increase in longevity in the United States and elsewhere has already brought about a slow-motion revolution in nearly every sector of society, from health care to housing to employment. But if radical life extension moves from the realm of fantasy to reality, that revolution will pick up considerable speed. Extending human life spans beyond those of even the oldest of our ancestors would raise a host of new social, political, economic, environmental, moral and other questions. Current ideas about marriage and parenting might change, for example, as people remain active for decades longer. Questions about environmental sustainability would likely increase if the number of people dying each year were to drop precipitously. And concerns about the divide between rich and poor might deepen if older people in wealthy countries spend large sums of money to prolong life while young children in the poorest nations continue to die of treatable diseases.

Religious organizations have traditionally played an important role in helping people think through end-of-life matters and respond to significant social changes. But since life extension has not made the journey from fantasy to fact, there has been little official or even quasi-official guidance in this area from churches and other religious groups. Still, religious people, from Pope Emeritus Benedict XVI to theologians and professors at religiously affiliated institutions, have started to think about the consequences of radical life extension. In particular, they have begun asking whether dramatically and artificially extending life is acceptable within the context of their religious traditions.

A New Science

Until recently, most scientists did not take longevity research very seriously. Even today, in many parts of the scientific community, anti-aging research is viewed as science fiction posing as science. But scientists at some of the most prestigious universities and biomedical research institutes in the world are looking for ways to extend the length – and improve the quality – of human life. While few of these scientists confidently predict that their work will end aging or dramatically prolong the human life span, many are cautiously optimistic about the prospect of making significant progress in the coming decades.

Scientists do not know exactly why people age and die. They understand many of the mechanisms that lead the body to break down and stop working over time, but the underlying causes of aging are still a mystery. One popular theory holds that humans are essentially programmed to die after they are no longer needed to raise the children they produce. According to this theory, evolution has ensured that people are strong during their fertile years so they can produce and rear offspring, but this bodily vigor subsides after the reproductive and parenting years are over.

In the last 200 years, advances in medicine, nutrition and public health have substantially increased human life spans. But these increases have been achieved largely by helping more children live to adulthood and old age rather than by pushing the boundaries of human aging well past their known limits, which most experts put at about 120 years. (The oldest person on record – Frenchwoman Jeanne Calment - lived to be 122).

Today, a host of companies offer different treatments, from human growth hormone (HGH) to testosterone, aimed at helping people turn back the clock. But these therapies have been widely shunned by the mainstream medical community and, so far, they have not been scientifically shown to lengthen a person's life span in any meaningful way. Some, like HGH, are alleged to be detrimental to long-term health.

Most gerontologists predict that the average life span in the developed world will continue to grow steadily and slowly. For example, in the U.S., life expectancy is projected to increase from roughly 78 today to 83 in 2050. In addition, the number of people who live past 90, or even 100, will continue to grow rapidly. Without a doubt, the world is getting greyer.

Adding Years by Subtracting Calories?

So where and how does longevity research fit into this equation? The answer may begin with starving rats in a lab in Ithaca, N.Y. It was there, in 1934, that scientists at Cornell University announced they had roughly doubled the life spans of laboratory rats by putting them on a near-starvation diet. This finding seemed to fly in the face of conventional medical wisdom. After all, doctors had already fingered nutritional deficiencies as the cause of a host of maladies, from scurvy to rickets. But in the decades that followed, similar experiments in what was soon called “caloric restriction” were shown to lengthen the average life spans of other organisms, from yeast cells and fruit flies to hamsters and dogs.

More recently, in 2009, scientists at the Wisconsin National Primate Research Center released the findings of a 27-year study showing that rhesus monkeys fed a diet with 30 percent fewer calories than usual were much less likely to contract the diseases of old age – including cancer, diabetes and heart disease - than those on a normal dietary regimen. Many longevity researchers hailed the Wisconsin experiment as particularly important because rhesus monkeys are among man’s closest biological relatives in the animal kingdom. It is one thing to prove that caloric restriction extends life in yeast cells, they said, and another to do so in a creature that shares 93 percent of man’s DNA. Equally important was the fact that the caloric-restriction experiments extended not only life span but *healthy* life span.

But the results of a parallel study, released in 2012, have called into question the claims made by the Wisconsin researchers. This second study - begun in 1987, five years after the Wisconsin research – has shown no appreciable difference in longevity between rhesus monkeys fed a normal diet and those given 30 percent fewer calories. The second experiment, conducted by the National Institute on Aging (NIA), did show a lower incidence of cancer in monkeys given the low-calorie diet when they were young and lower levels of blood sugar and cholesterol in another group started on fewer calories in old age. But so far, the monkeys fed the normal number of calories are, on average, living as long as those fed less.

For many researchers, the NIA study shows the safeguards built into the scientific method: Results that cannot be replicated are not valid. But others contend that while the NIA study has raised many legitimate questions about the effectiveness of caloric restriction, the jury is still out on whether eating fewer calories extends the lives of primates. For one thing, they say, the oldest monkeys involved in the NIA study are only 22 years old – five years younger than the oldest monkeys in the Wisconsin experiment. So while NIA researchers have been able to show no difference in longevity so far, they have not determined whether those monkeys who are still alive and still on the low-calorie diet will live longer than those fed a normal number of calories.

Still, even if the Wisconsin results ultimately prove more accurate than those put forth by the NIA, important questions remain about caloric restriction. First, there is no widely accepted proof that putting humans on an extreme low-calorie diet will help them in any way. Some people have embraced caloric restriction, but since people live a lot longer than mice or even rhesus monkeys, there has not been enough time to evaluate the long-term effects, if any, of such a diet. Second, there is evidence suggesting that less complex creatures derive much more benefit from caloric restriction than more complex species. In relative terms, starving roundworms (with an average life span of two weeks) are able to extend their lives much more than starving mice (who live a number of years). Finally, caloric restriction is very difficult for most people to maintain, and according to some studies, it tends to make those on the diet look and feel tired and run down.

Mimicking Caloric Restriction

The challenge of living on a near-starvation diet has led some researchers to search for a way to mimic caloric restriction without requiring people to drastically reduce their caloric intake. These scientists hope that one day people will simply take a pill or "flip" a genetic switch and fool their bodies into thinking they are living on fewer calories, without actually suffering the hardship of eating dramatically less.

One substance that might hold the key to mimicking caloric restriction is resveratrol, a compound found in the skin of grapes and certain other plants. Some scientists believe resveratrol is behind the much-ballyhooed evidence, known as the "French paradox," that regularly drinking moderate amounts of red wine could be good for a person's health.

In 2003, Harvard University biologist David Sinclair published his findings that high doses of resveratrol extended the healthy lives of yeast cells. More recently, Sinclair duplicated this experiment in mice and once again showed that those subjects taking resveratrol lived longer, on average, than those that did not.

Meanwhile, another ongoing study at the NIA involves giving resveratrol to rhesus monkeys. Because these monkeys live decades – much longer than yeast cells or mice – this NIA study will not directly focus on longevity and instead will examine whether the substance reduces the likelihood of the diseases of aging, such as diabetes and heart disease. If resveratrol reduces the incidence of these and other ailments, it might also increase longevity.

Sinclair believes that resveratrol works by activating a specific gene (SIRT1) that also is activated during periods of caloric restriction. SIRT1 is part of a family of seven genes, called sirtuins, that are thought to regulate the body's cellular waste-management system, thus keeping people healthy at the cellular level. As people age, sirtuins become less active and the body's cellular waste system becomes less effective, giving people a progressively greater chance of contracting certain disorders, including cancer and Alzheimer's disease.

Sinclair and others believe that caloric restriction and resveratrol activate or energize sirtuins, thus keeping the body's waste-management system in peak form throughout a person's life. Sirtris, a pharmaceutical company that Sinclair co-founded and pharmaceutical giant GlaxoSmithKline purchased in 2008 for $720 million, has tested three different synthetic versions of resveratrol in humans as potential therapies for age-related maladies and is exploring other ways to activate sirtuins.

So far, none of the drugs tested at Sirtris have borne fruit and, in 2013, Glaxo closed the company's offices. However, the pharmaceutical giant (through its larger, in-house research operation) continues to examine the medical potential of sirtuins, using research and even researchers from the now-defunct Sirtris. The hope is still that one or more compounds will help keep diabetes, heart disease and other age-related problems at bay and, as an added benefit, significantly extend healthy life span.

Some longevity researchers are placing their hopes on another drug, rapamycin, which also might prompt the body to mimic caloric restriction and thus extend life span. For years, rapamycin, an antibiotic, has been used as an immunosuppressant for organ transplant patients. But animal tests have shown that it might also have properties that promote longevity. For instance, in one experiment, researchers at Jackson Laboratory in Bar Harbor, Maine, found that rapamycin extended the average life span of female mice by 14 percent, even though the drug had not been properly administered during the first 600 days of the experiment. This mistake on the part of the lab meant that the mice did not actually begin feeling the impact of the drug until they were well into mouse middle age. Some scientists speculate that rapamycin could have extended the lives of the female mice by 20 percent or more if it had been administered early enough.

Proponents of rapamycin say it works by ramping up the body's cellular waste-removal system through suppression of the activity of a gene called mTOR, which produces certain proteins that help control cell metabolism. Those working with the compound hope that, in addition to extending life, rapamycin can be used to fight specific diseases, namely cancer.

Genetic Engineering and Other Methods

While some researchers have been trying to extend healthy life using chemical compounds, others have been trying a different approach: genetic engineering. The idea is that since different animals have radically different life spans, there must be genes in all living creatures that regulate age. If these genes can be found and effectively manipulated, life can be dramatically extended.

In the early 1980s, scientists began looking for so-called "Methuselah genes" in roundworms by turning on or off one particular gene and then seeing how long the mutated worms lived. Roughly 1,000 mutations later, in 1988, a biomedical researcher at the University of California at Irvine named Thomas Johnson showed that turning off a particular gene he called age-1 more than doubled the affected worm's life span.

Other researchers, notably Cynthia Kenyon of the University of California at San Francisco, have subsequently produced much longer-lived roundworms, with life spans up to six times greater than normal. A similar experiment with fruit flies, also at UC Irvine, yielded significant gains in life span as well. But whether such a longevity gene exists in humans – or even in higher-order animals, such as cats or monkeys - is still an open and hotly debated question.

Recently, scientists at the Albert Einstein College of Medicine in New York City have found a molecule that may provide another possible path to extending life.

In May 2013, the researchers announced that they had discovered a chemical called NF-κB in the brains of mice – specifically in the hypothalamus - that appears to trigger aging processes throughout the body. Suppressing the release of the chemical in middle-aged mice allowed them to live longer and with fewer age-related illnesses. If this phenomenon also occurs in people, the researchers said, it would better explain the causes of aging and could eventually lead to effective anti-aging treatments.

SENS and Singularity

Drugs such as resveratrol and rapamycin and experiments with Methuselah genes have the allure of a magic bullet: take a pill or flip a genetic switch and live an extra 20, 30 or even 40 healthy years. Some in the anti-aging movement, however, believe real gains will not be made by regularly ingesting one compound but through a combination of medical therapies.

One advocate of this approach is Aubrey de Grey, a former Cambridge University researcher and the closest thing the anti-aging movement has to a spokesman. De Grey, the chief science officer at an anti-aging think tank in Mountain View, Calif., the Strategies for Engineered Negligible Senescence (SENS) Research Foundation, believes aging will be conquered through a variety of "rejuvenation biotechnologies" that will repair and maintain the body indefinitely, much in the way a good mechanic can keep a vintage car running indefinitely. Under this scenario, various treatments, including stem cell and gene therapies, would be applied at the cellular level to halt the damage to the body caused by aging. "I'd say we have a 50/50 chance of bringing aging under what I'd call a decisive level of medical control within the next 25 years or so," de Grey said in a 2011 interview.

Some experts believe aging ultimately will be conquered by engineers and computer scientists rather than biomedical researchers. Ray Kurzweil, an American computer scientist and inventor whose work has led to the development of everything from checkout scanners at supermarkets to text-reading machines for the blind, says that what might seem outlandish today eventually will become possible because technological change is exponential rather than linear, meaning that technology is becoming more capable and more powerful at an ever-faster rate. "The reason information technology grows exponentially is that we use the latest technology to create the next," he said in "Transcendent Man," a 2009 documentary film about his life and ideas. "So each new generation of technology grows exponentially in capability and the speed of that process accelerates over time."

According to Kurzweil, who is now the director of engineering for Google, this accelerating pace of technical change is already producing computers and other machines that give biomedical researchers much greater capabilities. For instance, "it took us 15 years to sequence HIV; we sequenced SARS in 31 days," he said during a 2005 interview, referring to efforts to sequence the genomes of HIV in the 1980s and '90s and of SARS (Severe Acute Respiratory Syndrome) in 2003.

Using technology to improve traditional medical research is just the beginning, Kurzweil predicts. Soon, technology will give mankind the ability to place powerful machines in the human body to replace or improve existing biological systems. Machines, from pacemakers to cochlear implants, already play a huge role in medicine, and one does not need to be a science fiction writer or a professional futurist to see that the role of technology will continue to grow. Kurzweil and other scientists say that greater computing power combined with extreme miniaturization (nanotechnology) will allow scientists to put microscopic machines in the body - at first to protect and maintain people's organs and ultimately to effectively replace them. In essence, Kurzweil says, scientists will "reverse engineer" bodily systems so they can be replaced with much more reliable machines.

But Kurzweil does not stop at this "bionic man" scenario. Eventually, he claims, human beings will achieve immortality by fully merging with machines. Kurzweil predicts scientists will one day find a way to "reverse engineer" the brain and download human consciousness into it. Blood, bone, skin and organs (what Kurzweil and others call "wetware") will no longer be necessary. "Our ability to reverse engineer the brain - to see inside, model it, and simulate its regions – is growing exponentially," Kurzweil writes in his 2005 book, "The Singularity is Near: When Humans Transcend Biology." Once this reverse engineering is complete, Kurzweil says, not only will human beings be able to live potentially forever, but we "ultimately will be able to vastly expand our intelligence."

Many Questions, Many Answers

Even if scientists find ways to extend life only for decades rather than centuries, such a development would raise a variety of questions. Some of them fall into the realm of public policy: What would extra decades of life mean for the solvency of programs such as Social Security and Medicare? Would dramatically longer life spans make it substantially harder to promote environmental sustainability? Would having many more healthy older people lead to dramatic increases in unemployment among the young?

Life extension also would lead to many important social questions. For instance, would a doubling of the average life span change how many, if not most, people view marriage? Would people enter into marriage fully expecting, at some point, to marry again? And since children are often considered a hedge against mortality, would most people still want to have them? If they did, what would happen to traditional generational relationships? In a world where people may not look or act much older than their parents, grandparents and even great grandparents, would relationships remain the same?

There are many ethical issues, too. At a very basic level, some fear life extension could fundamentally alter people's sense of what it means to be human - and not for the better. According to Leon Kass, who chaired the President's Council on Bioethics under George W. Bush, one of the "virtues of mortality" is that it instils a desire to make each day count. Knowledge that one will soon die "is the condition for treasuring and appreciating all that life brings," he says.

Stanley Hauerwas, a noted author and theologian at Duke University's Divinity School, agrees that the certainty of death makes life more fulfilling. Without death, Hauerwas argues, love as we know it would cease to exist because it is the finite nature of life that prompts people to wholly commit themselves to others. "Death creates an economy that makes love possible," he said in a 2011 interview with the Pew Research Center. "If you lived forever, there would not be the necessity of loving this one, not that one. You could love them all."

But others see the possibility of significantly longer life as a blessing – one that people will adjust to and embrace, just as they have prior social and technological advances. De Grey of the SENS Foundation says that people fear much longer life spans only because they have talked themselves into believing that death is natural, and even good. He calls this a "pro-aging trance," which he says was "a sensible way of coping with the inevitability of aging" when it was inevitable. But now that aging and dying might not be inevitable, this mindset "becomes part of the problem."

When you come out of the trance and look at aging in the cold light of reality, de Grey says, you realize that it is not good or necessary. "It is a disease," he argues. Curing this disease, like eliminating any particular ailment, will lead to much less suffering and much more human happiness, de Grey predicts.

Life Extension and Faith

So far, the religious community has made relatively little contribution to the debate on radical life extension. Even the Roman Catholic Church - famous for its extensive teachings on nearly every aspect of life – has not issued any official pronouncements on the subject. But some members of the clergy, theologians, ethicists and other religious leaders are beginning to ponder the implications of dramatically extending life. Their views offer the first glimmers of how religious institutions might respond to radical life extension if it becomes a reality.

For those who follow the Abrahamic faith traditions – Judaism, Christianity and Islam - views on life and death are heavily influenced by the creation stories found in the Book of Genesis (for Jews and Christians) and the Quran (for Muslims). In particular, theologians focus on humanity's ultimate fall – as a result of disobedience to God - and subsequent expulsion from Paradise. It is clear in these narratives that after the expulsion, death became part of God's plan for humanity. In Genesis 3:19, for instance, God tells Adam and Eve that, as a result of their sin, they will "return to the ground, since from it you were taken; for dust you are and to dust you will return."

So does this mean that if radical life extension were to become possible, Jews, Christians and Muslims would uniformly object to it? Not necessarily. As with other ethical issues, such as abortion and stem cell research, the answer might depend on the particular denomination or religious tradition.

For instance, Paul Nelson, a Lutheran theologian at Wittenberg University in Springfield, Ohio, says that many mainline Protestant churches in the United States - including his own, the Evangelical Lutheran Church in America - probably would not oppose a new therapy that could dramatically or even indefinitely extend life. Instead, Nelson says, his church and other mainline Protestant denominations would approach such a development with caution and humility and avoid drawing bright lines. In fact, according to Nelson, some mainline churches might do little or nothing about it at the national level. Instead, he says, they would let local church leaders and their congregations decide how to respond to the issue. "I think they would look to the congregations, the grass roots, for guidance on something like this."

At the same time, some evangelical Protestant churches might be more inclined to publicly oppose, or at least warn against, new ways to dramatically prolong life. For instance, Albert Mohler, a leading thinker in the Southern Baptist Convention, the largest evangelical denomination in the U.S., has questioned the morality of trying to live significantly longer. Other evangelical leaders have expressed concern that life-extension therapies might involve human cloning or embryonic stem cell research, both of which violate the strong pro-life teachings of many evangelical churches.

But Nigel Cameron, a bioethicist and the president of the Center for Policy on Emerging Technologies, a think tank in Washington, D.C., believes that while church leaders might reject artificial longevity, many rank-and-file evangelicals – and most Americans - ultimately would accept and use life-extension therapies. "With a few exceptions, evangelicals adopt the custom and practice" of the broader culture, says Cameron, previously dean of the Wilberforce Forum, an evangelical Christian think tank in Washington.

There are some indications that the leadership of the Roman Catholic Church also might have serious reservations about life extension. The recently retired pope, Benedict XVI (Joseph Ratzinger), has expressed concern that dramatically postponing death could end up stripping people of their richest experiences - including the search for the transcendent and the need to have children - and leave society in a state of aged paralysis. "Humanity would become extraordinarily old, there would be no more room for youth [and] capacity for innovation would die," Benedict warned in a 2010 Holy Saturday homily.

On the other hand, some scholars believe the Catholic Church might make some allowances for more modest life-extension efforts, especially as part of a broader attempt to cure disease and alleviate suffering, says Father Nicanor Austriaco, a professor of biology at Providence College. He cites the church's mandate to help the aged and sick as the reason it has often supported new and even potentially problematic research, such as genetic engineering.

While Christians grapple with what they perceive as the possible costs and benefits of life extension, most Jews would be open to the development, say a number of Jewish rabbis of different traditions. Indeed, most Jews would likely view a prolonged human life span as an opportunity to better serve God and man, says Rabbi Barry Freundel, an ethicist and theologian who also leads an Orthodox Jewish congregation, Kesher Israel, in Washington, D.C. "The goal in Judaism is to make the world better and [extended life] would allow us to do more of that," Freundel says.

Radically extending life also would not be a problem for most Muslims, according to Aisha Musa, a professor of religion at Colgate University who has written about life extension from a Muslim perspective. According to Musa, Muslims believe Allah knows each person's exact life span – from birth to death, or what the Quran calls one's "term appointed" (Sura 40:67). As a result, many Muslims likely would see new life-extending technologies as part of God's plan for humanity.

Likewise, for Buddhists and Hindus, life extension probably would not create major concerns, according to thinkers in those faiths. Dramatically longer life would give Buddhists more time to learn wisdom and compassion and achieve nirvana, or freedom from suffering, says James Hughes, a former Buddhist monk who now serves as executive director of the Institute for Ethics and Emerging Technologies, a think tank in Hartford, Conn. Hindu scriptures, meanwhile, describe a "golden age" in the deep past when people lived 400 years. "Life extension would be seen as a return to this golden age," says Arvind Sharma, a professor of comparative religion at McGill University in Montreal who has written about Hinduism and life extension.

Whether dramatically extending life would lead to a golden age or a nightmarish dystopia is, at this point, unknown. It is more certain that life extension, if it came to pass, would challenge and in some cases alter many social, political and religious norms. And our most enduring institutions, especially religious institutions, would be called upon to guide people through the moral implications of this new reality.

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THE ETHICAL DIMENSIONS OF GEOENGINEERING: SOLAR RADIATION MANAGEMENT THROUGH SULPHATE PARTICLE INJECTION

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Introduction

The slow progress on an adequate policy solution in light of growing scientific understanding of the impacts of a warming world, limited success on efforts to mitigate the causes of anthropogenic climate change, and awareness of the high costs and the limits to adaptation have led some scientists and some policy-makers to consider geoengineering as a potentially viable option to avoid "threshold responses" and dangerous climate change. Some approaches to climate engineering, indeed, even proposals to field test climate engineering technologies such as ocean iron fertilization or increasing the reflectivity of the atmosphere to reduce the amount of sunlight that is absorbed, raise serious and complex ethical issues. Given this, proposals to deploy geoengineering technologies, or even to field test some of them, must be accompanied by serious consideration of the ethical dimensions of geoengineering. However, adequate ethical analyses must be grounded in and arise from a robust understanding of the relevant scientific accounts of such technologies and their potential impacts, and an appreciation of any correlated uncertainties. Indeed, ethical analysis may require and point to needed scientific research in cases where there are coupled ethical-epistemic issues, that is, where ethical judgments require additional knowledge. Hence, the science and ethics of geoengineering are intertwined.

A full review would have to address the ethical issues specific to each type of technology and approaches to implementation. In this paper, I will use concepts and dimensions of 'justice' as a lens through which to filter ethical questions, as well as focus on a particular geoengineering technique: solar radiation management through sulphate particle injection (SPI). I base this choice on current assessments that i) the technology needed to deploy this approach might potentially be scaled up over a relatively short period of time (± a decade) given that we may be able to model it on existing technologies, ii) many believe it has the best potential of all geoengineering approaches for cooling the planet rapidly and inexpensively; iii) given i) and ii), it is being given serious consideration by a significant number of scientists and policy-makers; iv) SPI, unlike most geoengineering approaches that focus on absorbing carbon from the atmosphere (carbon dioxide management technologies), has the potential to rapidly create a novel atmospheric state, with significant regional or global climatic effects, but one of which we have limited knowledge; and v) it would, on its own, not mitigate the high concentrations of greenhouse gases. For these reasons, SPI is arguably the approach most likely to be considered for deployment and partial deployment for testing, but is also the geoengineering approach most fraught with ethical issues.

The domain of ethical and coupled ethical-epistemic issues regarding SPI is very large. Indeed an entire entry could be written on each one of its many aspects. My aim in this essay will be rather to map a research agenda by working to identify some of the many issues in need of additional analysis regarding the ethical issues surrounding SPI. While I do not claim that the list is exhaustive, its length and complexity signal the importance of work on such topics prior to any decision as to whether to deploy SPI, as well as decisions about field testing.

Projected SPI Impacts on Temperature, Precipitation, and Society

Understanding the relevance of dimensions of justice requires an appreciation of the complexity of the impacts of SPI, and thus must be informed by an appreciation of our current scientific accounts and, in turn, work to identify value decisions embedded in the scientific analyses. Furthermore, ethical analysis must also be informed by an adequate analysis of the uncertainties in the science, and, ideally, partner with science to identify uncertainties due to missing domains of information that are required for adequate ethical analyses, as well as clarify which domains are due to deep uncertainties that are impossible to resolve through research. To frame the justice dimensions of SPI, this section provides an admittedly brief overview of some aspects of our current scientific understanding that are relevant to justice dimensions of SPI, while acknowledging that these details have been covered in greater strength elsewhere.

Modelling studies suggest that SPI, over the course of an 80-year simulation, would likely stabilize average global-mean surface air temperatures at levels approximately plus or minus half a degree from the temperature at which the SPI activities were initiated, but nonetheless may result in regional temperature disparities in that the poles may be relatively warmer and tropics cooler. Moreover, if SPI is not matched with serious mitigation efforts over time, the temperature differences between regions are likely to increase such that within six to seven decades “there is often no scenario that can place a region back within one standard deviation of both its baseline temperature and precipitation”. In other words, *different regions will likely experience different ‘climates’ the longer the forcings continue, and the forcing scenario needed to return one region to the designated baseline (e.g., a late twentieth-century climate) will be significantly different than that required for another region the longer SPI continues*.

Most current models also indicate likely negative impacts of SPI on the hydrological cycle: a global reduction in precipitation with more acute changes regionally, *likely leading to an intensification of both droughts and floods greater than would result from the effects of elevated* CO_2 *alone*. But the changes in precipitation will not be consistent across regions, and some regions will experience greater deviations than others in amount and seasonality of precipitation than others *dependent on the intensity and duration of the SPI*. Given the likelihood of distinct regional differences in the response to different levels of SPI, *the decision as to the choice of the optimal target for SPI (temperature or precipitation) is often regionally dependent*.

Furthermore, precipitation changes due to SPI would likely have *disproportionately negative impacts on those regions already experiencing high levels of poverty that have historically not significantly contributed to climate change*. Based on natural experiments such as the Mount Pinatubo eruption and information from computer simulations, SPI is likely to decrease average annual precipitation in Africa, South America, and Southeast Asia. Such changes in regional precipitation could compromise basic rights of individuals in these regions by resulting in food and water insecurity.

Regional differences in precipitation impacts, however, are not the only component of ethical issues raised by SPI targets. Irvine et al (2012) found there to be strong tensions between SPI targets that would aim to reduce the rate of temperature change vs. the rate of sea-level rise. They demonstrate that addressing sea-level rise would require significantly greater forcing than would be required to stop surface warming. *The greater forcings required for targeting sea-level rise, however, carry a significantly higher risk of abrupt or disruptive cooling.*

The temperature and precipitation impacts of SPI will not only impact human well-being, but will also affect ecosystem and species well-being. Furthermore, since CO_2 levels will likely continue to increase during SPI, ocean acidification will continue to be a serious problem. Ozone depletion may be another side-effect of SPI which would increase the risk of human health impacts as well as the well-being of various species and ecosystems.

The Question of Justice and Differential Impacts

There are at least five dimensions of justice relevant to SPI, including distributive justice, intergenerational justice, corrective justice, ecological justice, and procedural justice. While it is valuable to understand and examine each of these justice vectors, they almost always intersect in the case of SPI, greatly complicating the ethical analysis. In this section, I will discuss each aspect of justice relevant to SPI separately in order to clarify the types of issues relevant to each domain, following each description with a number of coupled ethical-scientific research questions in order to clarify the nature and range of coupled ethical-scientific issues that must be addressed to determine whether or not SPI could be considered as an ethically responsible choice. It is my intent to clarify the salience and complexity of issues of justice that are relevant to SPI, catalyze appreciation of the complexity of the intertwined ethical-scientific issues, and urge that this work be incorporated into the SPI research agenda. In addition, it is imperative that we recognize that these dimensions of justice often intersect and, indeed, at times conflict.

Distributive justice involves the principle that harms and benefits of an action should be fairly or equitably distributed. Strict egalitarian theorists argue, for example, that distributive justice requires that harms and benefits be shared equally. Rawlsian inspired difference theorists allow that differential impacts are justified on the condition that the least well off are better off than they were previously. In the case of SPI, the appropriate measure would be spatial- namely, do all regions of the Earth equitably benefit and are any of the resulting harms fairly distributed?

Research Questions:

1. Are the temperature and/or precipitation disparities caused to some regions by SPI outweighed by the benefits to other regions? What levels of confidence of impacts would be required to make this judgment?
   a. What would be a morally salient difference between regions that might justify a positive response? For example: density of population; uniqueness of species; vulnerability of region to temperature and precipitation change.
2. How should existing climate conditions be considered when assessing the impacts of SPI-induced changes in climate? For example, should a dry region getting drier be treated in the same way as wet region getting drier? Can we actually disaggregate the SPI impacts from other impacts on such conditions (e.g. land use changes, etc.)?
3. If temperature and precipitation impacts resulting from SPI cannot or should not simply be aggregated, what is the best way to quantify them? For example:
   a. In weighing impacts, what is the ethically responsible way to compare positive/negative impacts from temperature changes with those of precipitation?
   b. How are regional variations regarding the risks of higher temperatures vs. modified precipitation to be weighted?
4. Are there certain harms from SPI that could not be justified regardless of the benefits to others? For example:
   a. Compromising basic human rights, such as food, shelter, and health, of populations in some regions?
   b. Loss of a culturally significant way of life?
   c. Loss of citizenship (climate refugees) or in extreme cases an entire country's sovereignty (an entire country becoming uninhabitable due to extreme weather conditions such as flooding)?
   d. What levels of confidence in the probability of such impacts would be required to decide against using SPI?
5. Given that temperature and precipitation differences between regions are very likely to increase the longer SPI is continued, is there a time limit to SPI after which continued SPI would no longer be ethically justifiable?
6. Is the deployment of SPI to avoid "threshold" responses more just than the deployment of SPI to prevent global mean temperatures from rising above a certain degree? And if so, why?
7. Are there situations in which we would have a moral responsibility to use SPI rather than allow humans, other species, and ecosystems to suffer the harms of unremediated climate change? What would constitute the conditions that would make SPI a moral imperative? Are we able to measure such "thresholds"? What level of confidence in SPI's effectiveness regarding such a target should be required?
8. How do we weigh social benefits against risks to individuals? What measurements are actually possible and at what levels of confidence?

Intergenerational justice takes into consideration the impacts of SPI on future generations. Many see this version of justice as similar to that of distributive justice, but adding a temporal measure by comparing harms and benefits to current populations to those of future generations. However, even when attention is given to the impacts of a geoengineering approach to anthropogenic global warming upon future generations, an adequate ethical analysis must combine attention to impacts on future generations with attention to the spatial dimension of the impacts, as would an account of distributive justice, in those instances when future impacts might disproportionately benefit or harm different regions.

Research Questions:

1. How would the harms to future generations of long-term SPI deployment compare to other scenarios (such as business as usual, mitigation efforts without SPI, etc.)? Are we able to effectively model such scenarios? In such models, what is included as a benefit and what is included as a harm? Under what scenarios do the comparative benefit/harm ethically justify SPI deployment?
2. Are there SPI scenarios (intensity/duration) that are ethically untenable regardless of the benefit to current generations because they would put future generations at ethically unacceptable levels of risk? What level of confidence would be required to make this judgment?

Corrective justice diverges from the egalitarian approach of typical accounts of distributive justice, by arguing against an "aggregate" measure of benefits and harms and embracing a desert-based measure, which holds that harms and benefits ought to be shared among persons according to the degree persons deserve those harms and benefits. Through this lens, whether or not the impacts of an action are just requires that we consider the extent to which individuals or groups are morally deserving of those impacts. In the case of anthropocentric global warming, desert-based accounts of justice are often based on responsibilities for emissions. A key element is historical contributions to climate change that are disproportionately due to the activities of a group of industrialized nations which benefited from the industrialization and land use changes that led to high emission levels, but at the cost of the well-being of other countries. Indeed this form of corrective justice is recognized in the framework of the UNFCCC's "polluter pays" principle.

However, historical responsibility is not the only relevant measure. The inequities in emissions, and thus their inequitable contributions to the problem of anthropogenic climate change, continue to be an issue. For example, based on information from 2008, the United States emitted approximately four times the amount of CO_2 as India and more than ninety times the emission of CO_2 of Bangladesh. If responsibility is correlated with population, however, issues of desert get more complicated. For example, while China's total CO_2 emissions where approximately 20% higher than those of the US in 2008, average individual emissions in China are significantly lower than individual emissions in the US, where on average, each US citizen emits almost three times more CO_2 in comparison to individuals in China. But average emissions also ignores that individual emission levels are linked to economic class standing, with the poor even in the highest emitting countries often having low emissions and the wealthy in the lowest emitting countries often live life-styles that result in GHG emissions similar to wealthy individuals in high emitting countries. Corrective justice can also be de-coupled from responsibility for the causes of greenhouse gas emissions, and focus, as does prioritarianism, on the position that justice requires that benefits to the worst off should be given more weight than benefits to the better off.

And finally, just as intergenerational justice requires attention to the spatial distribution of harms and benefits at different times in the future (i.e., which regions at a particular time are likely to benefit or be harmed by the action), corrective justice must also embrace a temporal dimension, considering not only desert and culpability in the present case, but also projecting into the future to adequately apply such an account of justice.

Research Questions:

1. In choosing targets for SPI (temperature/sea level rise, etc.) should the decision be based on the greatest overall positive impacts or should those regions most negatively impacted by climate change be those regions that benefit most from SPI? Can we actually target in ways that would allow us to meet what is determined to be just targets? And how should historical and/or contemporary responsibility for greenhouse gas emissions be factored into the decision concerning which targets are the most just?
2. Should a "polluter pays" principle be applied to any responsibility for compensation for harms of SPI so that those most responsible for anthropocentric climate change become the most responsible? And if so which of the following measures are ethically relevant? Should these measures include discounting?
   a. Historical responsibility for greenhouse gas emissions;
   b. per capita emissions;
   c. a country's total emissions.
3. Temperature and/or precipitation changes will impact regions differently dependent on the general resilience/vulnerability of that region. How should the political-economic situation of a region be factored into the analysis of the impacts of SPI? Would such targets be technically feasible?
   a. Does justice require that benefits to poorer regions of SPI deployment provide these regions with greater benefits and fewer harms?
   b. Should those countries historically responsible for any political-economic vulnerabilities of a region be responsible for compensating vulnerable regions negatively impacted by SPI?
4. Are those regions that benefit most from SPI then responsible for compensating those regions which benefit less or which are negatively impacted? And if so, how should historical and/or contemporary responsibility for greenhouse gas emissions be factored into the decision about compensation?

5. Should current generations compensate future generations for the impacts of SPI?
6. What are ethically acceptable forms of compensation? For example, if a nation loses sovereignty because its land has been made inhabitable for SPI, does compensatory justice require providing its people with comparable land where they can claim sovereignty?
7. Should regions likely to be harmed be provided financial support for adaptation prior to or during SPI deployment? And who is responsible for providing that support? For example:
   a. historical responsibility for greenhouse gas emissions;
   b. benefits from SPI.

Ecological justice is a non-anthropocentric dimension of justice, which includes consideration of the impacts on nonhuman life and on ecosystem sustainability. Here, the emphasis of ethical analysis is the harms and benefits of SPI upon animals, plants, and ecosystems in general. As with the impacts of geoengineering on humans, the effects on other life forms and on ecosystems are dependent on the intensity and the length of SPI. And as with humans, animals, plants, and ecosystems in some regions will likely benefit, while others will likely be harmed. For example, geoengineering would not address the problem of ocean acidification. We know that high levels of CO2 alter ocean chemistry and can negatively affect the shell formation ability of marine calcifying organisms such as corals, with subsequent impacts on the ecosystem level. SPI will have the effect of lowering ultraviolet radiation levels, which might enhance plant health, but as this effect is likely intertwined with other changes, both to precipitation and to seasonal climate, the benefit might not be to the plants currently growing in a particular region, but rather to new species that may or may not be beneficial to ecosystem health.

Research Questions:

1. How do we weigh the moral standing of nonhuman species and/or ecosystems in comparison to that of humans in order to determine how to balance ethical responsibilities to current and future human populations with ethical responsibilities to current and future species and to ecosystems from SPI impacts?
2. Are there certain harms to species or ecosystems from SPI that could not be justified regardless of the benefits to humans? What levels of confidence would be required to make this judgment?

Procedural justice focuses once again on the human domain, but in this case on how to ensure that decision procedures are ethical. Following Rawls, many have argued that in order to be procedurally just, all those affected by the decision must have the ability to contribute to the decision process or have their interests represented. Others argue that procedural justice also requires that the rationales for the policy decisions be transparent and public, the decision process be based on relevant ethical principles, and the process allow for a mechanism for appeal and regulation to ensure fairness. In the instance of SPI, procedural justice issues are relevant in a number of domains, including who makes the decision about whether to test or implement SPI, when to stop testing or deploying SPI, as well as what should be the target of SPI.

Research Questions:

1. Since SPI will very likely affect all nations, must any just decision process for implementation be an international process?
   a. Is there an existing body like the United Nations that would be appropriate for this process? Does it provide sufficient representation of all those likely to be impacted?
2. Is the nation-state the ethically relevant representative group for making a just decision about SPI? If not, what would be?
3. How widespread must agreement be on SPI deployment for it to satisfy the demands of procedural justice?
4. What principles and procedures are best suited for making an ethical decision about SPI targets?
5. If there are individuals, groups, or nations who do not consent to SPI deployment, are they thereby more deserving of compensation for resulting harms?
6. Is there ever a condition in which it would be ethically acceptable for one group (e.g., a nation) or a small federation to make the decision to geoengineer without consultation with other groups/nations?

The applicability of the various dimensions of justice in the case of SPI arises from the well-recognized fact that SPI deployment will likely have serious side-effects. "A world cooled by managing sunlight will not be the same as one cooled by lowering emissions". But it is also linked to the fact that the speed and intensity of SPI deployment options correlate both to different climate "remediation" impacts as well as to different distributions of harms and benefits.

The Question of Intentionality

One of the reasons SPI is seen as raising serious ethical issues is the issue of intentionality. As noted by many ethicists writing on climate change, climate change is often not viewed as an ethical issue because it does not embody the characteristics of a paradigm moral problem. According to Jamieson " a paradigm moral problem is one in which an individual acting intentionally harms another individual; both the individuals and the harm are identifiable; and the individuals and the harm are closely related in time and space". While Jamieson argues persuasively that climate change nonetheless raises ethical issues, the link between moral responsibility and harm for SPI is arguably clearer and stronger due to the fact that those acting will be acting with knowledge that their actions have a high probability of violating the basic rights of people in some regions and could potentially be damaging to the rights of future generations as well as to nonhumans.

Jamieson refers to various types of geoengineering, particularly large-scale projects like SPI, as "intentional climate change." While we now know that many human activities from agricultural practices to energy choices are impacting the climate, the fact is that SPI has as its *primary intention* to modify the climate, and would be done knowing that there are various risks and highly probable harms, as noted above. Jamison argues that this places large-scale geoengineering projects like SPI in a different ethical domain in that the decision to modify the climate would be the intent of the actions, and thus the consequences of the action to deploy, including the unintended harms, would have a stronger ethical tie to the action.

Research Questions:

1. Is intentionally creating novel climates for the purposes of alleviating at least some of the harms of anthropocentric climate change ethically more problematic than business as usual greenhouse gas emissions now that we know that these emissions contribute to anthropocentric climate change?
2. SPI will only, at best, lessen some of the negative *impacts* of anthropocentric climate change and not the *causes*, thereby allowing greenhouse gases to continue to accumulate. Under what conditions, if any, is it ethically permissible to deploy SPI alone, that is, without mitigation efforts?
3. Does the fact that SPI intentionally creates novel and unpredictable climates entail that the individuals or groups who elect deployment are ethically responsible for any resulting harms?
4. If the intentionality of SPI entails greater ethical responsibility for resulting harms, does this result in a greater responsibility for those who agree to deployment to compensate those who are harmed?

The Question of Risk and Uncertainty

Intentionality often raises what has been called the “principle of double effect.” According to this principle, an action is ethically acceptable even if those acting cause or allow something bad as long as a) no evil is intended as an ends or a means; and b) the potential harm is not out of proportion with the anticipated good. However, the relationship between intention (to slow down the aggregate warming) and consequences (the harms and benefits of SPI) is made significantly more complex due to the fact that there are uncertainties linked to the probabilities of various impacts of SPI. Sidgwick, for example, influentially argues that “it is best to include under the term ‘intention’ all the consequences of an act that are foreseen as certain or probable; since it will be admitted that we cannot evade responsibility for any foreseen consequence of our acts by plea that we felt no desire for them”.

To include all the consequences of SPI deployment “that are foreseen as certain or probable” puts us in the domains of risk management and decision-making under uncertainty. At least some of the uncertainties relevant to SPI can be mitigated through additional scientific research. However, the question of testing itself raises a series of complex ethical questions. I will reserve a discussion of these concerns for the next section, and focus here on some of the ethical dimensions of decision making and risk management under conditions of uncertainty.

Various principles have been advocated by those working on the ethical dimensions of risk management. One is the principle of *justification*, which requires that for any action that entails the risk of harm, the benefits should outweigh the harm. While necessary, theorists argue that additional principles are required for an action to be ethically justifiable. One is the principle of *optimization* which implies that the likelihood of harm, the number of people exposed, and the magnitude of the harms "should all be kept as low as reasonably achievable, taking into account economic and societal factors - meaning that the level of safety should be the best under the prevailing circumstances maximizing the margin of benefit over harm". A third principle is that of *individual protection*, namely that the risk incurred by any individual should be restricted. This principle is designed to go beyond calculations of aggregate harms and focus attention on the magnitude of harms to individuals, in order to determine if there are limits that must be imposed on risk to individuals, for example, risk to satisfaction of basic needs.

Each of these principles requires transparency regarding the relevant value judgments that would be involved in its application. For example, the principle of justification would require weighting harms and benefits, which will likely be significantly different in kind. It will also have to take into consideration the various ethical dimensions noted above of differences in harms/benefits to various regions and between current and future generations. While perhaps providing guidelines for ethical decision-making, principles such as these still leave unsettled large domains of ethical analysis.

In addition to value judgments such as these that are involved in decisions concerning acceptable levels of risk, what to count as a harm and to whom/what, or how to weight different types of harms and/or benefits, the question of uncertainty raises additional ethical concerns. Various types of uncertainties are relevant to SPI. There is significant *epistemic uncertainty* in that we currently have incomplete knowledge about the impacts of SPI. Research on the impacts of SPI has been to date limited, and much of the research that has been done has been on natural experiments or modelling. To gain additional knowledge would likely require additional research, including at least partial deployment for testing, that itself raises coupled epistemic-ethical concerns as well be discussed below. Epistemic uncertainties can be reduced with sufficient time and resources, but ethical issues are relevant to how long we can wait to resolve such uncertainties before deciding whether or not to act. There is also *ontological uncertainty,* or what some have called deep uncertainty, in that aspects of the interactions between SPI and the natural systems are complex and nonlinear and thus unpredictable. These are uncertainties that are inherent in the complexity and coupled nature of the problem, and will not be mitigated with additional research. And third, SPI involves *ethical uncertainty*, in that there are different values and principles concerning how to weigh the harms/benefits of SPI, different judgments about the seriousness of those harms/benefits, different interpretations of who and what is to be included in the domain of moral standing (e.g. are nonhuman species and ecosystems to be included), and uncertainty about what future generations would view as the most salient ethical values or principles.

The ethical dimensions of decision-making under conditions of uncertainty is a new domain of ethical analysis, but one essential to SPI. Robust Decision Making and Dynamic

Adaptive Policy Pathways are two relatively recent approaches to decision-making under conditions of uncertainty, including ontological uncertainty. In both instances, the authors of these approaches appreciate the need to have ethical analyses closely intertwined in the analyses. While these approaches are not specific to SPI, they offer strategies for identifying ethically responsible ways to make decisions under conditions of uncertainty, including all three of the domains of uncertainty noted above. While uncertainty clearly makes responsible decision-making more difficult, it is a condition underlying many of our most trenchant global issues and thus work to identify ethically responsible decision-making approaches.

Research Questions:

1. To what extent must we reduce epistemological uncertainty in order to make an ethically responsible decision about SPI deployment?
2. Does ontological uncertainty about SPI deployment entail following a precautionary principle and not deploying at all or unless the potential harm of not doing so would clearly outweigh the uncertainty of doing so?
3. What are the best ways to manage ethical uncertainty about SPI?

The Question of Testing

As noted above, there is significant epistemic uncertainty surrounding SPI deployment, which some believe can and should be lessened through scientific testing. Indeed, it has been argued that there is an urgent need for research into geoengineering options such as SPI and that this research should go beyond modelling or the analysis of natural events, such as volcanic eruptions, and include field studies (Keith *et al.*, 2010). This type of testing is believed by some to be a necessary and ethically responsible step prior to partial and/or full-deployment of SPI for geoengineering and is seen as providing the basis for evaluating SPI technologies, testing the response of the system, and exploring possible unintended consequences. However, this position assumes that testing can occur that is a) significantly different than deployment and b) can lessen the epistemic uncertainties concerning SPI impacts.

Tuana et al. argue that testing in the defined above may not be possible for a variety of reasons. First, there are major uncertainties in climate models such as "vertical mixing in the ocean, evolution of polar ice (including ice sheets and glaciers), radiative feedbacks in the atmosphere, and clouds and precipitation" which would be highly sensitive to SPI deployment. Second, nonlinear feedbacks in the climate system can result in bifurcations of the system leading to abrupt shifts or transitions between states, such as the shutdown of the ocean's merdional overturning circulation, resulting in markedly different climate conditions. This is relevant to the question of testing as posed in that there may be a significant difference between small forcings of the kind that would be deployed for testing and the forcing levels and time trajectories needed for intentional climate modification. As forcing increases, the climate system could reach a threshold where it transitions to unstable conditions. In such a case, the SPI is happening in a significantly different climate state than that in which it was tested. Third, the system may exhibit hysteresis, or strong memory, in which reducing the forcing after the testing may not return the system to the original climate. Fourth, there will likely be delayed system responses to forcing. We know that different time scales govern ocean and atmosphere circulations, such that oceanic responses to SPI forcings may not manifest for years to decades longer than atmospheric responses. Because of this, impacts from SPI deployments for the purpose of testing may not be fully realized by the climate system until long after stopping the testing. Given the above noted variables, the type of learning projected from small-scale deployment for testing may not be possible. Given that these experiments can have negative impacts, both the ethical and the scientific justification for conducting such experiments is at issue.

Given these concerns there are a variety of ethical concerns regarding field-testing of SPI. Here I will identify some of the ethical issues directly related to field-testing *per se*, but it is important to underscore that many of the ethical issues noted about regarding issues of distributive justice, intergenerational justice, compensatory justice, ecological justice, and procedural justice apply to field-testing as well given the "side-effects." Note that these are examples of coupled scientific-ethical issues.

Research Questions:

1. What can be inferred from the limited scale experiments about the potential of a full-scale experiment, and what cannot?
   b. Is it possible to estimate the large-scale system response from a small-scale field test?
2. Will this knowledge be adequate for making an ethically responsible decision? Will this knowledge be sufficient to warrant the risks of field-testing?
3. What "side-effects" will result from field-testing and can they be predicted?
4. What scientific and ethical knowledge is required to responsibly decide whether to start SPI field-testing?
   a. What is the basis for deciding on acceptable risk levels for field-testing?
   b. What measures of impacts would be used to determine that the costs of field-testing are higher than the benefits of field-testing and should be halted?
   c. What level of learning would justify risks of side-effects?
5. What is the boundary between field-testing and deployment?

Political Risks of SPI Research and Testing

Another cluster of ethical issues concerns the psychological or political impact of SPI research or field-testing. Some researchers have raised the concern that geoengineering research might pose a moral hazard by causing people to be less concerned than they otherwise would be with respect to the risks posed by climate change. Some have begun to question whether or to what extent SPI research would impede research into other responses to climate change or reduce the political will to mitigate greenhouse gas emissions. There are also concerns that conducting SPI research would lead to unregulated, unilateral, or self-interested uses. Others have argued, to the contrary, that a credible threat of unilateral SPI might strengthen global mitigation efforts to avoid potential costly side effects of SPI.

Conclusion: The Centrality of Ethics for SPI

Given the potentially harmful impacts of SPI there is widespread agreement that SPI deployment raises important ethical issues. The 2009 Royal Society Report, to give just one example, affirmed that "it is clear that ethical considerations are central to decision-making in this field" and concluded that "the acceptability of geoengineering will be determined as much by social, legal and political factors, as by scientific and technical factors". However, in closing, it is important to stress that the ethical analyses of SPI are not simply *an addition* to the scientific analysis, to be put into play once the scientific research is complete. Ethically significant decisions are often *embedded in the scientific analysis itself*, as well as in how scientific models represent impacts and vulnerabilities.

Ethical analysis is dependent upon and must be intertwined with robust and sound scientific knowledge and effective and ethically responsible decision-making tools. As we have seen from the above discussion, since SPI testing and deployment would involve nontrivial risks of harm across many dimensions such as time, space, species, and socioeconomic status, an epistemically *and* ethically sound characterization of the underlying probabilities and risks requires a well-integrated analysis spanning fields such as Earth sciences, statistics, and economics. Hence, many of the ethical issues identified in this essay require additional and targeted coupled scientific-ethical research to ensure that we are developing epistemically responsible knowledge about geoengineering and comparing it to mitigation options.

One example of such an effort is the NSF funded research network for Sustainable Climate Risk Management (SCRiM). The aim of this research network is to study what are sustainable, scientifically sound, technologically feasible, economically efficient, and ethically defensible climate risk management strategies. One research domain of this group is "How do uncertain climate threshold responses affect the trade-offs between mitigation, carbon sequestration, and geoengineering?" One of the particular concerns of this network is to develop better integrated assessment models (IAMs) that better represent i) different time scales (from 50 years to centuries to millennia), ii) differences in regional impacts, and iii) potential low-probability/high impact events. Since these events are, thus far, quite poorly represented in the current generation of Earth system models, integrated collaboration between climate scientists, economists, and ethicists is essential to begin to address decision-relevant research questions that will allow us to respond to the types of complicated ethical questions identified in this essay. SCRiM thus provides a model for ethically responsible research on SPI that *embeds an analysis of ethical issues into the development of the scientific research itself*. Only in this way are we able to determine what types of knowledge we need to make ethically responsible decisions about SPI in the natural and social sciences.

Hence, while acknowledging the importance of the Royal Society's recognition that ethical issues are central to decision-making, what is in fact required goes beyond ethical analyses *of the science of geoengineering*. It is essential that the ethical analysis be coupled with scientific analysis by including ethicists within scientific research teams in order to infuse ethical analyses *into the science of geoengineering*. This will, of course, require scientists and funding agencies alike recognize the importance of such work and provide ample resources for coupled ethical-scientific analyses within SPI research. SCRiM is one example of such a practice, but the importance of this knowledge entails that far more work like this is required. I close then with the admonition that this important field of study be strengthened prior to and included in considerations of the feasibility of SPI deployment as well as pre-deployment for testing.

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Appendix 1

BIOTECHNOLOGY, ETHICS, AND THE POLITICS OF CLONING

Steven Best and Douglas Kellner

"O, wonder!
How many goodly creatures are there here!
How beauteous mankind is!
O brave new world
That has such people in't."
William Shakespeare, The Tempest

"We're ready to go because we think that the genie's out of her bottle."
Dr. Panos Zavos

"Anyone who thinks that things will move slowly is being very naive."
Lee Silver, Molecular Biologist

As we move into a new millennium fraught with terror and danger, a global postmodern cosmopolis is unfolding in the midst of rapid evolutionary and social changes co-constructed by science, technology, and the restructuring of global capital. We are quickly morphing into a new biological and social existence that is ever-more mediated and shaped by computers, mass media, and biotechnology, all driven by the logic of capital and a powerful emergent technoscience. In this global context, science is no longer merely an interpretation of the natural and social worlds, rather it has become an active force in changing them and the very nature of life. In an era where life can be created and redesigned in a petri dish, and genetic codes can be edited like a digital text, the distinction between "natural" and "artificial" has become greatly complexified. The new techniques of manipulation call into question existing definitions of life and death, demand a rethinking of fundamental notions of ethics and moral value, and pose unique challenges for democracy.

As technoscience develops by leaps and bounds, and as genetics rapidly advances, the science-industrial complex has come to a point where it is creating new transgenic species and is rushing toward a posthuman culture that unfolds in the increasingly intimate merging of technology and biology. The posthuman involves both new conceptions of the "human" in an age of information and communication, and new modes of existence as flesh merges with steel, circuitry, and genes from other species. Exploiting more animals than ever before, technoscience intensifies research and experimentation into human cloning.

This process is accelerated because genetic engineering and cloning are developed for commercial purposes, anticipating enormous profits on the horizon for the biotech industry. Consequently, all natural reality – from microorganisms and plants to animals and human beings – is subject to genetic reconstruction in a commodified "Second Genesis."

At present, the issues of cloning and biotechnology are being heatedly debated in the halls of science, in political circles, among religious communities, throughout academia, and more broadly in the media and public spheres. Not surprisingly, the discourses on biotechnology are polarized. Defenders of biotechnology extol its potential to increase food production and quality; to cure diseases and prolong human life; and to better understand human beings and nature in order to advance the goals of science. Its critics claim that genetic engineering of food will produce Frankenfoods that pollute the food supply with potentially harmful products; that biotechnology-out-of-control could devastate the environment, biodiversity, and human life itself; that animal and human cloning will breed monstrosities; that a dangerous new eugenics is on the horizon; and that the manipulation of embryonic stem cells violates the principle of respect for life and destroys a bona fide “human being.”

Interestingly, the same dichotomies that have polarized information-technology discourses into one-sided technophobic and technophilic positions are reproduced in debates over biotechnology. Just as we have argued that critical theories of technology are needed to produce more dialectical perspectives that distinguish between positive and negative aspects and effects of information technology (Best and Kellner, 2001), so too would we claim that similar approaches are required to articulate the potentially beneficial and perhaps destructive aspects of biotechnology. Indeed, current debates over cloning and stem cell research suggest powerful contradictions and ambiguities in these phenomena that render one-sided positions superficial and dangerous. Parallels and similar complexities in communication and biotechnology are not surprising given that information technology provides the infrastructure to biotechnology that has been constituted by computer-mediated technologies involved in the Human Genome Project, and, conversely, genetic science is being used to push the power and speed of computers through phenomena such as “gene chips.”

As the debates over cloning and stem cell research indicate, issues raised by biotechnology combine research into the genetic sciences, perspectives and contexts articulated by the social sciences, and the ethical and anthropological concerns of philosophy. Consequently, we argue that intervening in the debates over biotechnology require supradisciplinary critical philosophy and social theory to illuminate the problems and their stakes. In addition, debates over cloning and stem cell research raise exceptionally important challenges to bioethics and a democratic politics of communication. Biotechnology is thus a critical flashpoint for ethics and democratic theory and practice. For contemporary biotechnology underscores the need for more widespread knowledge of important scientific issues; participatory debate over science, technology, values, and our very concept of human life; and regulation concerning new developments in the biosciences, which have such high economic, political, and social consequences.

More specifically, we will demonstrate problems with the cloning of animals that for now render the cloning of humans unacceptable. In our view, human cloning constitutes a momentous route to the posthuman, a leap into a new stage of history, with significant and potentially disturbing consequences. We will also take on arguments for and against stem cell research and contend that it contains positive potential for medical advances that should not be blocked by problematic conservative positions. Nonetheless, we believe that the entire realm of biotechnology is fraught with dangers and problems that require careful study and democratic debate. The emerging genomic sciences should thus be undertaken by scientists with a keen sense of responsibility and accountability, and be subject to intense public scrutiny and open discussion. Finally, in the light of the dangers and potentially deadly consequences of biotechnology, we maintain that embracing its positive potential can be realized only in a new context of cultivating new sensibilities toward nature, engaging in ethical and political debate, and participating in political struggles over biotechnology and its effects.

Brave New Barnyard: The Advent of Animal Cloning

"The idea is to arrive at the ideal animal and repeatedly copy it exactly as it is."
Dr. Mark Hardy

From its entrenched standpoint of unqualified human superiority, science typically first targets objects of nature and animals with its analytic gaze and instruments. The current momentous turn toward cloning is largely undertaken by way of animals, although some scientists have already directly focused on cloning human beings (see below). While genetic engineering creates new "transgenic" species by inserting the gene from one species into another, cloning replicates cells to produce identical copies of a host organism by inserting its DNA into an enucleated egg. In a potent combination, genetic engineering and cloning technologies are used together in order, first, to custom design a transgenic animal to suit the needs of science and industry (the distinction is irrevocably blurred) and, second, to mass reproduce the hybrid creation endlessly for profitable peddling in medical and agricultural markets.

Cloning is a return to asexual reproduction and bypasses the caprice of the genetic lottery and random shuffling of genes. It dispenses with the need to inject a gene into thousands of newly fertilized eggs to get a successful result. Rather, much as the printing press replaced the scribe, cloning allows mass reproduction of a devised type, and thus opens genetic engineering to vast commercial possibilities. Life science companies are poised to make billions of dollars in profits, as numerous organizations, universities, and corporations move toward cloning animals and human stem cells, and patenting the methods and results of their research.

To date, science has engineered thousands of varieties of transgenic animals and has cloned sheep, calves, goats, bulls, pigs, mice, and a cat. Though still far from precise, cloning nevertheless has become routine. What's radically new and startling is not cloning itself, since from 1952 scientists have replicated organisms from embryonic cells. Rather, the new techniques of cloning, or "nuclear somatic transfer," from adult mammal body cells constitutes a new form of human reproduction. These methods accomplish what scientists long considered impossible - reverting adult (specialized) cells to their original (non-specialized) embryonic state where they can be reprogrammed to form a new organism. In effect, this startling process creates the identical twin of the adult that provided the original donor cell. This technique was used first to create Dolly, and subsequently all of her varied offspring.

Dolly and Her Progeny

Traditionally, scientists considered cloning beyond the reach of human ingenuity. But when Ian Wilmut and his associates from the Roslin Institute near Edinburgh, Scotland, announced their earth-shattering discovery in March 1997, the "impossible" appeared in the form of a sheep named Dolly, and a "natural law" had been broken. Dolly's donor cells came from a six-year-old Finn Dorset Ewe. Wilmut starved mammary cells in a low-nutrient tissue culture where they became quiescent and subject to reprogramming. He then removed the nucleus containing genetic material from an unfertilized egg cell of a second sheep, a Scottish Blackface, and, in a nice Frankenstein touch, fused the two cells with a spark of electricity. After 277 failed attempts, the resulting embryo was then implanted into a third sheep, a surrogate mother who gave birth to Dolly in July 1996.

Many critics said Dolly was either not a real clone or was just a fluke. Yet, less than two years after Dolly's emergence, scientists had cloned numerous species, including mice, pigs, cows, and goats, and had even made clones of clones of clones, producing genetic simulacra in mass batches as Huxley envisioned happening to human beings in Brave New World. The commercial possibilities of cloning animals were dramatic and obvious for all to behold. The race was on to patent novel cloning technologies and the transgenic offspring they would engender.

Animals are being designed and bred as living drug and organ factories, as their bodies are disrupted, refashioned, and mutilated to benefit meat and dairy industries. Genetic engineering is employed in biomedical research by infecting animals with diseases that become a part of their genetic make-up and are transmitted to their offspring, as in the case of researchers trying to replicate the effects of cystic fibrosis in sheep. Most infamously, Harvard University, with funding from Du Pont, has patented a mouse - OncoMouse - that has human cancer genes built into its genetic makeup and are expressed in its offspring.

In the booming industry of "pharming" (pharmaceutical farming), animals are genetically modified to secrete therapeutic proteins and medicines in their milk. The first major breakthrough came in January 1998, when Genzyme Transgenics created transgenic cattle named George and Charlie. The result of splicing human genes and bovine cells, they were cloned to make milk that contains human proteins such as the blood-clotting factor needed by hemophiliacs. Co-creator James Robl said, "I look at this as being a major step toward the commercialization of this [cloning] technology."

In early January 2002, the biotech company PPL announced that they had just cloned a litter of pigs which could aid in human organ transplants – on the eve of the publication of an article by another company Immerge Bio Therapeutics that claimed they had achieved a similar breakthrough. The new process involved creation of the first "knockout" pigs, in which a single gene in pig DNA is deleted to eliminate a protein that is present in pigs which is usually violently rejected by the human immune system. This meant that a big step could be made in the merging of humans and animals, and creating animals as harvest-machines for human organs.

Strolling through the Brave New Barnyard, one can find incredible beings that appear normal, but are genetic satyrs and chimera. Cows generate lactoferrin, a human protein useful for treating infections. Goats manufacture antithrombin III, a human protein that can prevent blood clotting, and serum albumin, which regulates the transfer of fluids in the body. Sheep produce alpha antitrypsin, a drug used to treat cystic fibrosis. Pigs secrete phytase, a bacterial protein that enables them to emit less of the pollutant phosphorous in their manure, and chickens make lysozyme, an antibiotic, in their eggs to keep their own infections down.

"BioSteel" presents an example of the bizarre wonders of genetic technology that points to the erasure of boundaries between animate and inanimate matter, as well as between different species. In producing this substance, scientists have implanted a spider gene into goats, so that their milk produces a super-strong material - BioSteel - that can be used for bulletproof vests, medical supplies, and aerospace and engineering projects. In order to produce vast quantities of BioSteel, Nexia Biotechnologies intend to house thousands of goats in 15 weapons-storage buildings, confining them in small holding pens.

Animals are genetically engineered and cloned for yet another reason, to produce a stock of organs for human transplants. Given the severe shortage of human organs, thousands of patients every year languish and die before they can receive a healthy kidney, liver, or heart. Rather than encouraging preventative medicine and finding ways to encourage more organ donations, medical science has turned to xenotransplantation, and has begun breeding herds of animals (with pigs as a favored medium) to be used as organ sources for human transplantation.

Clearly, this is a very hazardous enterprise due to the possibility of animal viruses causing new plagues and diseases in the human population (a danger which exists also in pharmaceutical milk). For many scientists, however, the main concern is that the human body rejects animal organs as foreign and destroys them within minutes. Researchers seek to overcome this problem by genetically modifying the donor organ so that they knock out markers in pig cells and add genes that make their protein surfaces identical to those in humans. Geneticists envision cloning entire herds of altered pigs and other transgenic animals so that an inexhaustible warehouse of organs and tissues would be available for human use. In the process of conducting experiments such as transplanting pig hearts modified with a human gene into the bodies of monkeys, companies such as Imutran have caused horrific suffering, with no evident value to be gained given the crucial differences among species and introducing the danger of new diseases into human populations.

As if billions of animals were not already exploited enough in laboratories, factory farms, and slaughterhouses, genetic engineering and cloning exacerbate the killing and pain with new institutions of confinement and bodily invasion that demand millions and millions more captive bodies. Whereas genetic and cloning technologies in the cases described at least have the potential to benefit human beings, they have also been appropriated by the meat and dairy industries for purposes of increased profit through the exploitation of animals and biotechnology. It's the nightmarish materialization of the H. G. Wells scenario where, in his prophetic 1904 novel The Food of the Gods, scientists invent a substance that prompts every living being that consumes it to grow to gargantuan proportions.

Having located the genes responsible for regulating growth and metabolism, university and corporate researchers immediately exploited this knowledge for profit. Thus, for the glories of carnivorous consumption, corporations such as MetaMorphix and Cape Aquaculture Technologies have created giant pigs, sheep, cattle, lobsters, and fish that grow faster and larger than the limits set by evolution.

Amidst the surreality of Wellsian gigantism, cattle and dairy industries are engineering and cloning designer animals that are larger, leaner, faster-growing value producers. With synthetic chemicals and DNA alteration, farmers can produce pigs that mature twice as fast and provide at least twice the normal amount of sows per litter as they eat 25% less feed, and cows that produce at least 40% more milk. Since 1997, at least one country, Japan, has sold cloned beef to its citizens. But there is strong reason to believe that U.S. consumers - already a nation of guinea pigs in their consumption of genetically modified foods - have eaten cloned meat and dairy products. For years, corporations have cloned farmed animals with the express purpose of someday introducing them to the market, and insiders claim many already have been consumed. The National Institute of Science and Technology has provided two companies, Origen Therapeutics of California, and Embrex of North Carolina, with almost $5 million to fund research into factory farming billions of cloned chickens for consumption. With the Food and Drug Administration pondering whether to regulate cloned meat and dairy products, it's a good bet they are many steps behind an industry determined to increase their profits through biotechnology. The future to come seems to be one of cloned humans eating cloned animals.

While anomalies such as self-shearing sheep and broiler chickens with fewer feathers have already been assembled, some macabre visionaries foresee engineering pigs and chickens with flesh that is tender or can be easily microwaved, and chickens that are wingless so they won't need bigger cages. The next step would be to just create and replicate animal's torsos – sheer organ sacks – and dispense with superfluous heads and limbs. In fact, scientists have already created headless embryos of mice and frogs in grotesque manifestations of the kinds of life they can now construct at will.

Clearly, there is nothing genetic engineers will not do to alter or clone an animal. Transgenic "artist" Eduardo Kac, for instance, commissioned scientists at the National Institute of Agronomic Research in France to create Alba, a rabbit that carries a fluorescent protein from a jellyfish and thus glows in the dark. This experiment enabled Mr. Kac to demonstrate his supremely erudite postmodern thesis that "genetic engineering [is] in a social context in which the relationship between the private and public spheres are negotiated"! Although millions of healthy animals are euthanized every year in U.S. animal "shelters," corporations are working to clone animals, either to bring them back from the dead, or prevent them from "dying" (such as in the Missyplicity Project, initiated by the wealthy "owners" of a dog who want to keep her alive indefinitely). Despite alternatives to coping with allergies problems and the dangers with cloning animals, Transgenic Pets LLC is working to create transgenic cats that are allergen-free. It is time to examine concretely what cloning means for animal existence.

Transgenic Travesties

The agricultural use of genetics and cloning has produced horrible monstrosities. Transgenic animals often are born deformed and suffer from fatal bleeding disorders, arthritis, tumors, stomach ailments, kidney disease, diabetes, inability to nurse and reproduce, behavioral and metabolic disturbances, high mortality rates, and Large Offspring Syndrome. In order to genetically engineer animals for maximal weight and profit, a Maryland team of scientists created the infamous "Beltway pig" afflicted with arthritis, deformities, and respiratory disease. Cows engineered with bovine growth hormone (rBGH) have mastitis, hoof and leg maladies, reproductive problems, numerous abnormalities, and die prematurely. Giant supermice endure tumors, damage to internal organs, and shorter life spans. Numerous animals born from cloning are missing internal organs such as hearts and kidneys. A Maine lab specialized in breeding sick and abnormal mice who go by names such as Fathead, Fidget, Hairless, Dumpy, and Greasy. Similarly, experiments in the genetic engineering of salmon have led to rapid growth and various aberrations and deformities, with some growing up to ten times their normal body weight. Cloned cows are ten times more likely to be unhealthy as their natural counterparts. After three years of efforts to clone monkeys, Dr. Tanja Dominko fled in horror from her well-funded Oregon laboratory. Telling cautionary tales of the "gallery of horrors" she experienced, Dominko said that 300 attempts at cloning monkeys produced nothing but freakishly abnormal embryos that contained cells either without chromosomes or with up to nine nuclei.

For Dominko, a "successful" clone Like Dolly is the exception, not the rule. But even Dolly is inexplicably overweight and there was evidence in May 1999 that she may be suspectible to premature aging. On January 4, 2002, there were reports that Dolly has arthritis and her creator Ian Wilmut said on a BBC broadcast: "There is no way of knowing if this is down to cloning or whether it is a coincidence." Moreover, cloned mice have also become extremely obese, and cloned cows have been born with abnormally large hearts and lungs.

A report from newscientists.com argues that genes are disrupted when cultured in a lab, and this explains why so many cloned animals die or are grossly abnormal. On this account, it is not the cloning or IVF process that is at cause, but the culturing of the stem cells in the lab, creating major difficulties in cloning since so far there is no way around cloning through cultured cells in laboratory conditions.

A team of U.S. scientists at the M.I.T. Whitehead Institute examined 38 cloned mice and learned that even clones which look healthy suffer genetic maladies and scientists found the mice cloned from embryonic stem cells had abnormalities in the placenta, kidneys, heart, and liver. They feared that the defective gene functioning in clones could, wreak havoc with organs and trigger foul-ups in the brain later in life and that embryonic stem cells are highly unstable. "There are almost no normal clones," study author and MIT biology professor Rudolf Jaenisch, explained. Jaenisch claims that only 1-5% of all cloned animals survive, and even those that survive to birth often have severe abnormalities and die prematurely.

As we argue below, these risks make human cloning a deeply problematic undertaking. Pro-cloning researchers claim that the "glitches" in animal cloning eventually can be worked out. In January 2001, for example, researchers at Texas A&M University and the Roslin Institute claimed to have discovered a gene that causes abnormally large cloned fetuses, a discovery they believe will allow them to predict and prevent this type of mutation. It is conceivable science someday will work out the kinks, but for many critics this assumes that science can master what arguably are inherent uncertainties and unpredictable variables in the expression of genes in a developing organism. A recent study showed that some mouse clones seem to develop normally until an age the equivalent of 30 years for a human being; then there is a spurt of growth and they suddenly become obese. Mark Westhusin, a cloning expert at Texas A&M, points out that the problem is not that of genetic mutation, but of "genetic expression," that genes are inherently unstable and unpredictable in their functioning. Another report indicates that a few misplaced carbon atoms can lead to cloning failures. Thus, any small errors in the cloning process could lead to huge disasters, and the prevention of all such "small errors" seems to presume something close to omniscience.

Yet, while most scientists are opposed to cloning human beings (rather than stem cells), and decry it as "unacceptable," few condemn the suffering caused to animals or position animal cloning research itself as morally problematic, and many scientists aggressively defend animal cloning. Quite callously and arbitrarily, for example, Jaenisch proclaims, "You can dispose of these animals, but tell me – what do you do with abnormal humans?" The attitude that animals are disposable is a good indication of the problems inherent in the mechanistic science that still prevails and a symptom of callousness toward human life that worries conservatives.

Despite the claims of its champions, the genetic engineering of animals is a radical departure from natural evolution and traditional forms of animal breeding.

Further, human cloning takes biotechnology into a new and, to many, frightening posthuman realm that begins to redesign the human body and genome. Cloning involves manipulation of genes rather than whole organisms. Moreover, scientists engineer change at unprecedented rates, and can create novel beings across species boundaries that previously were unbridgeable. Ours is a world where cloned calves and sheep carry human genes, human embryo cells are merged with enucleated cows' eggs, monkeys and rabbits are bred with jellyfish DNA, a surrogate horse gives birth to a zebra, a dairy cow spawns an endangered gaur, and tiger cubs emerge from the womb of an ordinary housecat.

The ability to clone a desired genetic type brings the animal kingdom into entirely new avenues of exploitation and commercialization. From the new scientific perspective, animals are framed as genetic information that can be edited, transposed, and copied endlessly. Pharming and xenotransplantation build on the system of factory farming that dates from the postwar period and is based on the confinement and intensive management of animals within enclosed buildings that are prison-houses of suffering.

The proclivity of the science-industrial complex to instrumentalize animals as nothing but resources for human use and profit intensifies in an era in which genetic engineering and cloning are perceived as a source of immense profit and power. Still confined for maximal control, animals are no longer seen as whole species, but rather as fragments of genetic information to be manipulated for any purpose.

Weighty ethical and ecological concerns in the new modes of animal appropriation are largely ignored, as animals are still framed in the 17th century Cartesian worldview that views them as nonsentient machines. As Jeremy Rifkin (1997: 35) puts it, "Reducing the animal kingdom to customized, mass-produced replications of specific genotypes is the final articulation of the mechanistic, industrial frame of mind. A world where all life is transformed into engineering standards and made to conform to market values is a dystopian nightmare, and needs to be opposed by every caring and compassionate human being who believes in the intrinsic value of life."

Patenting of genetically modified animals has become a huge industry for multinational corporations and chemical companies. PPL Therapeutics, Genzyme Transgenics, Advanced Cell Technology, and other enterprises are issuing broad patents claims on methods of cloning nonhuman animals. PPL Therapeutics, the company that "invented" Dolly, has applied for the patents and agricultural rights to the production of all genetically altered mammals that could secrete therapeutic proteins in their milk. Nexia Biotechnologies obtained exclusive rights to all results from spider silk research. Patent number 4,736,866 was granted to Du Pont for Oncomouse, which the Patent Office described as a new "composition of matter." Infigen holds a U.S. patent for activating human egg division through any means (mechanical, chemical, or otherwise) in the cloning process.

Certainly, genetics does not augur solely negative developments for animals. Given the reality of dramatic species extinction and loss of biodiversity, scientists are collecting the sperm and eggs of endangered species like the giant panda in order to preserve them in a "frozen zoo." It is indeed exciting to ponder the possibilities of a Jurassic Park scenario of reconstructing extinct species (as, for example, scientists recently have uncovered the well-preserved remains of a Tasmanian tiger and a woolly mammoth). In 2001, European scientists cloned a seemingly healthy mouflon lamb, a member of an endangered species of sheep, and ACT produced the first successful interspecies clone when a dairy cow gave birth to a gaur, an endangered wild ox native to Southeast Asia (although it died of an infection only two days later). Currently, working with preserved tissue samples, ACT is working to bring back from extinction the last bucardo mountain goat which was killed by a falling tree in January 2000.

But critics dismiss this as a misguided search for a technofix that distracts focus from the real problem of preserving habitat and biodiversity. Even if animals could be cloned, there is no way to replicate habitats lost forever to chainsaws and bulldozers. Moreover, the behaviors of cloned animals would unavoidably be altered and they would end up in zoos or exploitative entertainment settings where they exist as spectacle and simulacra. Animals raised through interspecies cloning such as the gaur produced by ACT will not have the same disposition as if raised by their own species and so for other reasons will not be less than "real." Additionally, there is the likelihood that genetic engineering and cloning would aggravate biodiversity loss to the extent it creates monolithic superbreeds that could crowd out other species or be easily wiped out by disease. There is also great potential for ecological disaster when new beings enter an environment, and genetically modified organisms are especially unpredictable in their behavior and effects.

Still, cloning may prove a valuable tool in preserving what can be salvaged from the current extinction crisis. Moreover, advances in genetics also may bypass and obviate pharming and xenotransplantation through use of stem cell technologies that clone human cells, tissues, or perhaps even entire organs and limbs from human embryos or an individual's own cells. Successful stem cell technologies could eliminate at once the problem of immune rejection and he need for animals. There is also the intriguing possibility of developing medicines and vaccines in plants, rather than animals, thus producing a safer source of pharmaceuticals and neutraceuticals and sparing animals suffering. None of these promises, however, brighten the dark cloud cloning casts over the animal kingdom, or dispel the dangers of the dramatic alteration of human life.

Clones R' Us: The Portent of Human Replication

"Human cloning could be done tomorrow."
Alan Trounson, In Vitro Fertilization clinician. Monash University

Thus, the postmodern adventure of the reconstruction of nature begins with the genetic engineering of transgenic animals and the cloning of numerous animal species for agricultural, medical, and "scientific" purposes, while in fact biotechnology is being positioned as a field for prodigious profits. The fate of the human is inseparable from the future of our fellow animal species, as they are the launch pad for the redesign of human nature. With the birth of Dolly, a new wave of animal exploitation arrived, and anxiety grew about a world of cloned humans that scientists said was technically feasible and perhaps inevitable. Ian Wilmut, head of the Roslin Institute team that cloned Dolly, is an example of an animal and stem cell cloning advocate who repudiates human replication. Like Jaenisch and numerous others, Wilmut believes human cloning is unethical, unnecessary, and dangerous, and that the inevitable deformities would be cruel to both the parents and children involved (Wilmut et al 2000).

Wilmut feels human cloning should not be attempted until there is a quantum leap in cloning technologies, an advance he feels is at least 50 years away. Most of all, Wilmut fears that the drive toward human cloning could cause a backlash against all cloning, and thereby thwart the far more important research into cloning stem cells for therapeutic purposes. For Wilmut, the authentic purpose for biotechnology is to cure disease and improve agriculture. Whatever his intention, however, many scientists and entrepreneurs inspired by the Roslin Institute's work have aggressively pursued the goal of human cloning as the true telos of genomic science. Driven by market demands for clones of infertile people, of those who have lost loved ones, of gays and lesbians who want their own children, of people who want to clone themselves or family members to provide needed organs, and of numerous other client categories, doctors and firms are actively pursuing human cloning.

The Race to Clone Humans

"Even if we had to transfer the laboratory on a boat located in international waters, the human cloning project will continue."

Rael, ex-race car driver and founder of Clonaid company

Pro-human cloning forces include Richard Seed who shocked the world in 1997 by declaring that he was prepared to clone himself, later appending the project to his wife. The Raelins, a wealthy Quebec-based religious cult, believe that all humans were cloned in laboratories by alien scientists and claim that their "Cloinaid" project is about to produce the first human clone (which they initially projected to be ready by November 2001). Infertility specialists Severino Antinori and Panayiotis Zanos openly announce their intent to clone humans, in defiance of any national law if necessary. The Council for Secular Humanism is a broad coalition of scientists, philosophers, authors, and politicians who decry the influence of religion in the cloning debates and champion the cause of human cloning, as they assure us that cloning will not create any "moral predicaments beyond the capacity of human reason to resolve." And the Human Cloning Foundation is an Internet umbrella group for diverse clonistas who see cloning as the best hope for curing infertility and diseases and promoting longevity.

One bioethicist estimates that there are currently at least a half dozen laboratories around the world doing human cloning experiments. While cloning human beings is illegal in the U.S., Britain, German, Japan, and elsewhere, in many countries in Asia, Russia, and Brazil, it is perfectly legal and human cloning is being pursued both openly and clandestinely. In fact, there are at least two known cases where human embryos have been cloned, but the experiment was terminated. According to Wired (9.02, February 2001: 128):

In 1988, a scientist working at Advanced Cell Technology in Worcester, Massachusetts took a human somatic cell, inserted it into an enucleated cow egg, and started the cell dividing to prove that oocytes from other species could be used to create human stem cells. He voluntarily stopped the experiment after several cell divisions. A team at Kyung Hee University in South Korea said it created an embryonic adult human clone in 1999 before halting the experiment, though some doubt that any of this really happened. Had either of these embryos been placed in a surrogate mother, we might have seen the first human clone.

In November 2001, ACT created a global sensation with (misleading) reports they had cloned human embryos. While many scientists think human cloning is possible and inevitable, some think it is likely human clones already exist, perhaps in hideous form where they are studied on an island, such as was portrayed in H.G. Wells' The Island of Dr. Moreau (see Best and Kellner 2001). The breeding of monstrosities in animal cloning, the pain and suffering produced, and the possibility of assembly-production of animals and humans should give pause to those who want to plunge ahead with human cloning. Animal cloning experiments produced scores of abnormalities and it is highly likely that human cloning would do the same – a possibility more likely given the increased complexity of human beings.

The possibilities of producing serious human defects raises ethical dilemmas as well as the question of the social responsibility involved in the care of deformed beings produced by human cloning experiments. Fervant pro-cloners like Antinori and Zavos deny there are any risks to cloning humans and claim that there is "enough information" to proceed with confidence. If pressed to admit there might be "mistakes," they simply write them off as necessary means to the end of reproductive freedom and medical progress. Ignoring the availability of frozen embryos and existing children for adoption, they claim the "right to reproduce" as crucial for human beings, and argue that this "right" – which in fact does not exist in any social constitution – outweighs any risks to the baby or to society as a whole, once the doorway is opened to the world of human cloning.

But, at present, what sane person would want to produce a possibly freakish replication of him or herself or a dead loved one? What are the potential health risks to women who would be called upon to give birth to human clones, at least before artificial wombs make women, like men, superfluous to the reproductive process? Who will be responsible for caring for deformed human clones that parents renounce? Is this really an experiment that the human species wants to undertake so that self-centered infertile couples can have their own children (apparently some can only love a child with their own DNA), or misinformed narcissists can spawn what they think will be their carbon-copy twins? What happens if human clones breed? What mutations could follow? What might result from long-range tampering with the human genome as a consequence from genetic engineering and cloning?

Furthermore, until scientists figure out how to clone minds, cloning inevitably involves reproduction of bodily DNA, raising questions of what sorts of minds cloning might produce. What if cloned humans appear to be mentally defective or aberrant as a result of the technology? What might be the long-term costs of the perceived short-term benefits that cloning may produce? Already, scientists are raising the issue of "cognitive deficiencies" in cloned animals and certainly this problem is relevant to the project of human cloning.

In addition, as the TV-series "Dark Angel" illustrates, there is the possibility of a military appropriation of cloning to develop herds of Ubermenschen (although no two would be exactly alike). Indeed, will commodification of the human genome, eugenics, designer babies, and genetic discrimination all follow as unavoidable consequences of helping infertile couples and other groups reproduce, or will human cloning become as safe and accepted as in vitro fertilization (IVF), once also a risky and demonized technology? Will developing countries be used as breeding farms for animals and people, constituting another form of global exploitation of the have-nots by the haves? What are the consequences of the commodification of the human genome, and the patenting of stem cells and their research methods?

With so many questions and uncertainties that arise, it is clear that the project of human cloning is being approached in a purely instrumental and mechanistic framework that doesn't consider long-term consequences to the human genome, social relations, or ecology. Or, if social relations and consequences are considered, likely this is from the perspective of improving the Nordic stock and creating an even deeper cleavage between rich and poor since, without question, only the rich will be able to afford genetically designed and/or cloned babies with superior characteristics. This situation could change if the state sponsors cloning welfare programs or the prices of a "Gen-Rich" (Silver 1998) baby drop like computers, but the wealthy will already have gained a decisive advantage and "democratic cloning" agendas beg the question of the soundness of human cloning in the first place.

Problems with Human Cloning

Thus, we have serious worries about biotechnology not only due to the colonialist history of science and capitalism, the commodification of the life sciences, and how genetic technologies have already been abused for profit and power by corporations like Monsanto and Du Pont, but also because of the reductionistic paradigm informing molecular engineering. Ironically, while biology helped to shape what theorists conceive as a postmodern physics through evolutionary and holistic emphases, the most advanced modes of biological science – genetic engineering and cloning research - have not advanced to the path of holism and complexity (see Best and Kellner, 2001). Rather, biotechnology seems to have regressed to the antiquated errors of atomism, mechanism, determinism, and reductionism. The new technosciences and the outmoded paradigms (Cartesian) and domineering mentalities (Baconian) that informs them generates a volatile mix, and the situation is gravely exacerbated by the commercial imperatives driving research and development, the frenzied "gene rush" toward DNA patenting.

Yet if human cloning technologies follow the path of IVF technologies, they eventually will become widely accepted, even though currently large percentages of U.S. citizens oppose it (90% according to some polls in summer 2001). Alarmingly, scientists and infertility clinics have taken up human cloning technologies all-too-quickly. After the announcement of the birth of Dolly, many were tripping over themselves to announce emphatically that they would never pursue human cloning. Nonetheless, only months later, these same voices began to embrace the project. The demand from people desperate to have babies, or "resurrect" their loved ones in conjunction with the massive profits waiting to be made, is too great an allure for corporations to resist - a demand begging for supply. The opportunistic attitude of cloning advocate Panayiotis Zavos is all-too-typical: "Ethics is a wonderful word, but we need to look beyond the ethical issues here. It's not an ethical issue [!]. It's a medical issue. We have a duty here. Some people need this to complete the life cycle, to reproduce."

In his attempt to dispel the ineliminable moral quandaries surrounding cloning, Zavos has confused "need" with desire, and reduced humans to crude reproduction machines. Yet, as his statement shows, defenders of cloning and biotechnology argue for the primacy of individual reproductive rights over potential risks to society as a whole. They believe that science is valuable to the extent that it increases freedom, individuality, and choice, as if embryos were a soft drink and what an "individual" chooses in this case is not of enormous consequence for future humanity, to say nothing of the deformed children who surely will be the guinea pigs of science. Of them, Zavos can only say, "We're ready to face those mishaps It's part of any price that we pay when we develop new technology."

There are indeed legitimate grounds for anxiety and loathing of cloning, but most fears of human cloning are irrationally rooted in what Leon Kass claims is an intuitive human repulsion – the "yuk" factor – toward something that is seemingly "unnatural". Many such clonophobic arguments are weak. The standard psychological objections, in particular, are poorly grounded. We need not fear Hitler armies assembling because the presumption of this dystopia - genetic determinism - is false (although certain desirable traits could be cloned which might prove useful for military powers). Nor need we fear individuals unable to cope with lack of their own identity since identical twins are able to differentiate themselves from one another relatively well and they are even more genetically similar than clones would be. Nor would society always see cloned humans as freaks, as people no longer consider test-tube babies alien oddities, and there are anywhere from 20,000 to 200,000 such humans existing today (figures vary widely). The physiological and psychological dangers are real, but in time cloning techniques could be perfected so that cloning might be as safe, if not safer than babies born through a genetic throw-of-the-dice, or IVF.

A strong objection against human cloning and genetic engineering technologies is that they could be combined to design and mass reproduce desirable traits, bringing about a society organized around rigid social hierarchies and genetic discrimination - as vividly portrayed in the film Gattaca (1997). This was, of course, the nightmare of Aldous Huxley, who continued H.G. Wells' speculations on a genetically engineered society and creation of new species. Indeed, with only trivial qualifications, Huxley's Brave New World (1932) of genetic engineering, cloning, addictive pleasure drugs (soma), entertainment and media spectacles, and intense social engineering has arrived. Huxley thought cloning and genetic engineering were centuries away from realization, but in fact they began to unfold a mere two decades since his writing of Brave New World in the early 1930s. Technocapitalism cannot yet, for instance, biologically clone human beings, but it can clone them in a far more effective way -- socially. Whereas biological clones would have a mind of their own, since the social world and experiences that conditioned the "original" could not be reproduced, social cloning according to a given ideological and functional model is far more controlling. That is why Huxley's sequel work, Brave New World Revisited (1958) focused on various modes of social conditioning and mind control.

Defenders of cloning and biotechnology argue that current science is geared toward increasing individuality and choice, enabling people to design their own children and within limits to mold their own body. Already parents can genetically choose the sex of their child. Soon, they might be able to isolate and remove genes that cause obesity, addictions, and a host of fatal illness, as well as to engineer genes that would enhance intelligence, strength, athleticism, physical attractiveness, and other desirable traits.

Of course, as Baudrillard argues, cloning is connected as well to the fantasy of immortality, to defeating the life-death cycle. Techno-utopians fantasize about the possibility of cloning one's body, or downloading one's memories into another body or a machine, thereby achieving immortality and alleged continuity of selfhood. The Raelians promote cloning as a chance for "eternal life." In the current social setting, it's no surprise that cryogenics - the freezing of dead human beings in the hope they might be regenerated in the future through medical advances – is a booming global industry.

Currently, the human race stands at a crossroads and must make crucial choices concerning the future of the human, including the issue of cloning. Whatever one's philosophical and ethical conceptions of cloning, it is clear that at present human cloning is unacceptable. Proponents of human cloning argue that it took hundreds of attempts to develop a test-tube baby and that trial-and-error is simply the scientific method. We need to ask, however, if such costs are legitimate when the benefits are not yet clear. While one might sympathize with couples that fervently desire a child and utilize IVF, legions of unwanted children await adoption, and it is difficult to justify the great leap forward to cloning through these kinds of rationale.

Therapeutic vs. Reproductive Cloning: The Debate Over Stem-Cell Research

"It is not unrealistic to say that stem cell research has the potential to revolutionize the practice of medicine."

Dr. Harold Varmus, former NIH director

"The 20th century was the drug therapy era. The 21st century will be the cell therapy era."

George Daleuy, biologist with the Whitehead Institute for Biomedical Research, Cambridge, Massachusetts

Full-blown human reproductive cloning is problematic for numerous reasons, and we reject it on the grounds that it lacks justification and portends a world of eugenics and genetic discrimination rooted in the creation and replication of desired human types. Yet scientists are also developing a more benign and promising technology of stem cell research, or "therapeutic cloning." The controversy around embryonic stem cell research - because it involves using and destroying cells from frozen human embryos - remains one of the key debates of our time, important enough to provoke a major policy crisis for the Bush Administration and to warrant an address to the nation on prime-time TV in August 2001. Rarely do scientific debates erupt into the public forum, and although the technical aspects are difficult and complex, the ethical and medical stakes are clear enough to command a national debate.

In 1998, Dr. James A. Thomson, a developmental biologist at the University of Wisconsin, announced to the scientific world that he had isolated embryonic stem cells, thus portending a new era of "regenerative medicine" based on the renewal and recreation of the body's cells. Stem cells are the primitive master cells of the body that differentiate into functions like skin, bone, nerve, and brain cells (the body produces over 200 cell types). The goal of stem cell research is to program the development of stem cells toward specific functions in order to replace lost or damaged cells, tissues, and organs. Using similar technological breakthroughs such as led to Dolly, stem cell research involves cloning cells from a wide range of human tissue, or very young human embryos (around 5 days of age) and aborted fetal tissues.

In the debates over stem cell research, an important distinction emerged between adult stem cells, that are derived from blood, bone marrow, fat and other tissues, and embryonic stem cells from discarded IVF cultures, aborted fetuses, or embryos created in a lab. While scientists are experimenting with adult stem cells, the current consensus is that embryonic cells are the most pliable and hence have the most regenerative potential. In July 2001, the National Institute of Health issued a report that "Stem cells from adults and embryos both show enormous promise for treating an array of diseases but at this early stage, cells from days-old embryos appear to offer certain key advantages." As Ceci Connolly summarized it: "Embryonic stem cells are more plentiful and therefore easier to extract, can be grown and made to multiply in the laboratory more easily and appear to have the uncanny ability to develop into a much wider array of tissues." In fact, embryonic and adult stem cell research may each contribute to significant medical and health advancement. According to Senator Bill Frist (R-Tenn), the only medical doctor in Congress, an opponent of abortion, and key science advisor to the Bush administration: "because both embryonic and adult stem cell research may contribute to significant medical and health advancement, research on both should be federally funded within a carefully regulated, fully transparent framework that ensures respect for the moral significance of the human embryo."

Scientists argue that therapeutic cloning has tremendous medical potential. Early in life, for example, each individual could have their stem cells frozen to create their own "body repair kit" if they developed a disease or even lost a limb. There would be no organ shortages, no rejection problem, and no need for animal exploitation as the cells would be their own. Although there has of yet been no significant advances in human research, and the results so far confined to animals are not necessarily applicable to human beings, stem cell research nonetheless shows remarkable potential for revolutionary breakthroughs in medicine. Among their achievements with mice, rats, pigs, and fetal monkeys, scientists have directed stem cells to produce insulin, to induce growth of brain cells, and to form new blood vessels in hearts, thereby suggesting immense contributions to curing diabetes, Alzheimer's or Parkinson's, and heart disease. Still, while industries and media often hype the research as producing immanent medical revolutions, many scientists believe breakthroughs in gene therapy and therapeutic cloning are likely decades away and that explanations have been unduly raised.

Another crucial distinction involves using embryonic stem cells from IVF discards and cloning embryos for the explicit sake of research. Whereas Britain allows both kinds of stem cell research, and thus condones embryo cloning for therapeutic purposes, the Bush administration highly restricts the use of IVF stem cell lines and condemns embryonic cloning. Yet many scientists argue that the ideal source of stem cells for regenerative medicine would not only be those derived from IVF embryos, but from embryos cloned from a patient's own cells, as the derived stem cells would be one's own and in theory far less susceptible to rejection. Thus, there is a medical justification for cloning human embryos and embryo cloning will be crucial to regenerative medicine.

On January 22, 2001, Britain became the first country to legalize human embryo cloning, with the proviso, perhaps impossible to enforce, that all clones would have to be destroyed after 14 days of development, and never implanted in a human womb. Britain thus endorsed therapeutic cloning, while banning reproductive cloning. On the whole, Britain seems to have more scientifically advanced and democratic political guidelines and policies on cloning than the U.S. While a ban on human reproductive cloning is pending, therapeutic cloning is allowed under rigorous guidelines. Britain was ahead in the process of IVF since the birth of Louise Brown in England in 1978. Moral philosophers have been debating bioethical issues and there has been much public discussion. Parliament set up an agency on Human Fertilization and Embryology Authority that license fertility clinics and research institutions that study human embryos. The agency has kept detailed statistics of the number of human embryos created, planted and destroyed in fertility clinics. The U.K. is establishing a stem cell bank that would be run as a public resource, in a way similar to the Human Genome Project. Hence, existing stem cell lines and techniques are available to any qualified researcher, and Britain has passed progressive laws banning genetic discrimination and mandating that therapies and medical advances that come out of genetic research will be available to and benefit everyone through its National Health Service.

In the U.S. and elsewhere, many religious groups and hard-core technology critics vituperate against stem cell research as "violating" the "inherent sanctity of life." To be sure, there is an ethical issue at stake in creating embryos for research purposes, or even using IVF cells, as living matter is being used as a means to some end other than its own existence. Clearly, using IVF cells that are going to be destroyed regardless is less objectionable than cloning an embryo for the sake of "harvesting" its cells then terminating it, but many religious groups and conservatives nonetheless vehemently oppose all forms of stem cell research and any manipulation of life, no matter what profound medical consequences may result. "Anyone truly serious about preventing reproductive human cloning must seek to stop the process from the beginning," Leon Kass, later to be Bush's cloning czar, proclaimed before a House judiciary subcommittee in June 2001.

To challenge stem cell research, many conservatives (and some liberals) are recycling philosophical arguments from earlier debates over abortion. The Pope and critics of stem cell research argue that once a sperm and egg are mixed into an embryo, no matter what the medium, there is a human life with all of its rights and sacredness. Others claim that a human life exists only when the embryo is implanted in a mother and has undergone the beginnings of the maturation process. Some medical experts assert that 14 days is the crucial dividing line when a backbone and organs begin to develop, while many pro-choice proponents argue that a fetus itself is not yet fully a human being. These earlier philosophical arguments have been revived in the stem-cell debate to legitimize conflicting scientific and political positions. In the context of stem cell research, religious conservatives repeat the same question-begging argument: (1) a human embryo is a human being; (2) it is wrong to take a human life; (3) therefore, it is wrong to "destroy" an embryo. The most controversial claim of the argument, in premise (1), is either just assumed, or defended through dogmatic claims that "life begins at conception," when, arguably, there is no real conception in a petri dish holding a 5-day-old cell mass.

Ultimately, the debate comes down to the philosophical issue of what constitutes a human being. Opponents of therapeutic human cloning and embryonic stem cell research claim that "conception" takes place when an embryo is produced, even in a petri dish. Critics of this notion of human life argue that an embryo is a merger of sperm and egg that takes place in five or six days and is called a blastocyst, which scientists distinguish from a fetus. Scientists further claim that an embryo only attains fetus-status at around 14 days when it develops a "primitive streak," the beginnings of a backbone. Up until that point, a single embryo can divide into identical twins, and two embryos can merge into one, leading Ronald Green, a Dartmouth bioethicist to conclude: "It is very clear that you cannot speak of a human individual in the first 14 days of development. How can one speak of the presence of an individual soul if the embryo can be split into two or three?"

Clearly, it is difficult to say when human life begins, and claims that it emerges "at conception" are simplistic. So far human life has only been produced from fetuses that mature in the womb of a woman's body, and thus we have trouble conceiving that 5 day-old embryos in a petri dish are human. It also might be pointed out that only about one in eight embryos implanted through IVF achieves fetal status, and few conservative critics worry over the doomed embryos or question the ethics of IVF as a whole, a technology that produces surplus cells for medical research. The fact that embryos typically used for stem cell research are leftover from couples using in vitro fertilization, and are marked for destruction regardless, strongly undercuts the force of the argument against embryonic stem cells.

Indeed, the slippery slope argument beloved by conservatives (the direct and unavoidable path from stem cell research to fetus farms and a society peopled by clones) is easily turned against them. In the age of cloning where possibly any cell can be replicated and turned into an embryo, one might argue that it is unethical even to scrape any skin cells as they too are potential human beings. Silly, perhaps, but this is also an indicator of the surreality of the postmodern adventure. In an amazing alchemy, scientists can directly transform cells of one kind into another. PPL Therapeutics succeeded in transforming a cow's skin cell into a basic stem cell, and then refashioned it as a heart cell. Further, researchers are working on cultivating spermless embryos, studying how to prod unfertilized eggs to grow to produce stem cells. Geron has created heart cells that beat in a petri dish. Clearly, the implications of stem cell research are staggering.

One should not see the use or creation of human embryos for medical resources as a trivial issue, but the debate over therapeutic cloning involves competing values and conceptions of the nature of a human being. This is a conflict between a small clump of cells no bigger than the period at the end of this sentence, and full-fledged human beings in dire medical need. In a conflict between a tiny ball of non-sentient cells or fetuses that would be disposed of regardless, and full-fledged human beings suffering from diseases that lack a cure, most people would reasonably choose the latter category of human persons.

In June 2002, however, an attempt to ban all embryonic cloning, supported by President Bush, was defeated in the U.S. Senate. This resulted in part because advocates of embryonic research rejected the category of "therapeutic cloning" and even "embryo". The argument was that it is not a question of "cloning," but of "somatic cell nuclear transfer" or "regenerative medicine," working on eggs in a test tube that have not been fertilized by sperm and is thus not a human embryo. This change in terminology won over some conservatives who were being pressured to support potentially significant medical research, although critics decried the effort as use of "linguistic cloaking devices" and continued their polemic against all cloning.

Thus, while many conservatives defend the "sanctity" of embryonic cells, and so far are successfully thwarting stem cell research, thousands of people continue to suffer and die from Alzheimer's, Parkinson's disease, diabetes, paralysis, and other afflictions. This is a strange position for "pro-life" and "compassionate" conservatives to defend. The entire moral quandary may be blunted, however, as scientists are now discovering ways to use stem cells derived from umbilical cords, bone marrow, and even fat and brain cells, and have cloned and implanted kidneys in a cow.

Deferring the Brave New World: Challenges for Ethics and Democracy

"Cloning is inefficient in all species. Expect the same outcome in humans as in other species: late abortions, dead children and surviving but abnormal children,"

Ian Wilmut

"Is there any risk too great or any reason too trivial for you not to attempt human cloning?"

Alta Charo, University of Wisconsin bioethicist, speaking to Antinori and Zavos

Thus by summer of 2001, a technical and esoteric debate over stem cells, confined within the scientific community during the past years, had moved to the headlines to become the forefront of the ongoing science wars -- battles over the cultural, ethical, and political implications of science. The scientific debate over stem cell research in large part is a disguised culture war, and conservatives, liberals, and radicals have all jumped into the fray. In our own case, coming from a perspective of critical theory and radical democratic politics, we reject conservative theologies and argue against conflations of religion and the state. Likewise, we question neo-liberal acceptance of corporate capitalism and underscore the implications of the privatization of research and the monopolization of knowledge and patents by huge biotech corporations. In addition, we urge a deeper level of public participation in science debates than do conservatives or liberals and believe that the public can be adequately educated to have meaningful and intelligent input into technical issues such as cloning and stem cell research which have tremendous human and ethical implications.

As we have shown, numerous issues are at stake in the debate over cloning, having to do not only with science, but also with religion, politics, economics, democracy, ethics, and the meaning and nature of human beings and all life forms as they undergo a process of genetic reconstruction. Thus, our goal throughout this paper has been to question the validity of the cloning project, particularly within the context of a global capitalist economy and its profit imperative, a modernist paradigm of reductionism, and a Western sensibility organized around the concept of the domination of nature. Until science is recontextualized within a new holistic paradigm informed by a respect for living processes, by democratic decision making, and by a new ethic toward nature, the genetic sciences on the whole are in the hands of those governed by the imperatives of profit. Moreover, they are regulated by politicians who do not have a good grasp of the momentous issues involved, requiring those interested in democratic politics and progressive social change to educate and involve themselves in the politics of biotechnology.

We have already entered a new stage of the postmodern adventure in which animal cloning is highly advanced and human cloning is on the horizon, if not now underway. Perhaps little human clones are already emerging, with failures being discarded, as were the reportedly hundreds of botched attempts to create Louise Brown, the first test-tube baby, in 1978. At this stage, human cloning is indefensible in light of the possibility of monstrosities, dangers to the mother, burdens to society, failure to reach a consensus on the viability and desirability of cloning humans, and the lack of compelling reasons to warrant this fateful move. The case is much different, however, for therapeutic cloning, which is incredibly promising and offers new hope for curing numerous debilitating diseases. But even stem cell research, and the cloning of human embryos, as we have seen, is problematic, in part because it is the logical first step toward reproductive cloning and mass production of desired types, which unavoidably brings about new (genetic) hierarchies and modes of discrimination.

We thus need to discuss the numerous issues involved in the shift to a posthuman, postbiological mode of existence where the boundaries between our bodies and technologies begin to erode as we morph toward a cyborg state. Our technologies are no longer extensions of our bodies, as Marshall McLuhan stated, but rather are intimately merging with our bodies, as we implode with other species through the genetic crossings of transgenic species. In an era of rapid flux, our genotypes, phenotypes, and identities are all mutating. Under the pressure of new philosophies and technological change, the humanist mode of understanding the self as a centered, rational Subject has transformed into new paradigms of communication and intersubjectivity, and information and cybernetics.

Despite these shifts, it is imperative that elements of the modern Enlightenment tradition be retained, as it is simultaneously radicalized. Now more than ever, as science embarks on the incredible project of manipulating atoms and genes through nanotechnology, genetic engineering, and cloning, its awesome powers must be measured and tempered through ethical, ecological, and democratic norms in a process of public debate and participation. The walls between "experts" and "laypeople" must be broken down along with the elitist norms that form their foundation. Scientists need to enter dialogical relations with the public to discuss the complexities of cloning and stem cell research, to make their positions clear and accessible, as well as accountable and responsible, while public intellectuals and activists need to become educated in biotechnology in order to engage in debate in the media or public forums on the topics.

Scientists should recognize that their endeavors embody specific biases and value choices, subject them to critical scrutiny, and seek more humane, life-enhancing, and democratic values to guide their work. Respect for nature and life, preserving the natural environment, humane treatment of animals, and serving human needs should be primary values embedded in science. And when these values might conflict, as in the tension between the inherent value of animals and human "needs," the problem must be addressed as sensitively as possible.

This approach is quite unlike how science so far has conducted itself in many areas. Most blatantly, perhaps, scientists, hand in hand with corporations, have prematurely rushed the genetic manipulation of agriculture, animals, and the world's food supply while ignoring important environmental, health, and ethical concerns. Immense power brings enormous responsibility, and it is time for scientists to awaken to this fact and make public accountability integral to their ethos and research. A schizoid modern science that rigidly splits facts from values must give way to a postmodern metascience that grounds the production of knowledge in a social context of dialogue and communication with citizens. The shift from a cold and detached "neutrality" to a participatory understanding of life that deconstructs the modern subject/object dichotomy derails realist claims to unmediated access to the world and opens the door to an empathetic and ecological understanding of nature.

In addition, scientists need to take up the issue of democratic accountability and ethical responsibility in their work. As Bill Joy argued in a much-discussed Wired article in July 2000, uncontrolled genetic technology, artificial intelligence, and nanotechnology could create catastrophic disasters, as well as utopian benefits. Joy's article set off a firestorm of controversy, especially his call for government regulation of new technology and "relinquishment" of development of potentially dangerous new technologies, as he claimed biologists called for in the early days of genetic engineering, when the consequences of the technology were not yet clear. Arguing that scientists must assume responsibility for their productions, Joy warned that humans should be very careful about the technologies they develop, as they may have unforeseen consequences. Joy noted that robotics was producing increasingly intelligent machines that might generate creative robots that could be superior to humans, produce copies of themselves, and assume control of the design and future of humans. Likewise, genetic engineering could create new species, some perhaps dangerous to humans and nature, while nanotechnology might build horrific "engines of destruction" as well as of the "engines of creation" envisioned by Eric Drexler.

Science and technology, however, not only require responsibility and accountability on the part of scientists, but also regulation by government and democratic debate and participation by the public. Publics need to agree on rules and regulations for cloning and stem cell research, and there need to be laws, guidelines, and regulatory agencies open to public input and scrutiny. To be rational and informed, citizens need to be educated about the complexities of genetic engineering and cloning, a process that can unfold through vehicles such as public forums, teach-ins, and creative use of the broadcast media and internet.

An intellectual revolution is needed to remedy the deficiencies in the education of both scientists and citizens, such that each can have, in Habermas' framework, "communicative competency" informed by sound value thinking, skills in reasoning, and democratic sensibilities. Critical and self-reflexive scrutiny of scientific means, ends, and procedures should be a crucial part of the enterprise. "Critical", in Haraway's analysis, signifies "evaluative, public, multiactor, multiagenda, oriented to equality and heterogeneous well-being". Indeed, there should be debates concerning precisely what values are incorporated into specific scientific projects and whether these serve legitimate ends and goals. In the case of mapping the human genome, for instance, enormous amounts of money and energy are being spent, but almost no resources are going to educating the public about the ethical implications of having a genome map. The Human Genome Project spent only 3 to 5 percent of its $3 billion budget on legal, ethical, and social issues, and Celera spent even less.

A democratic biopolitics and reconstruction of education would involve the emergence of new perspectives, understandings, sensibilities, values, and paradigms that put in question the assumptions, methods, values, and interpretations of modern sciences, calling for a reconstruction of science (on "new science" and "new sensibilities". At the same time, as science and technology co-construct each other, and both coevolve in conjunction with capitalist growth, profit, and power imperatives, science is reconstructing - not always for the better - the natural and social worlds as well as our very identities and bodies. There is considerable ambiguity and tension in how science will play out given the different trajectories it can take. Unlike the salvationist promises of the techoscientific ideology and the apocalyptic dystopias of some of its critics, we see the future of science and technology to be entirely ambiguous, contested, and open. For now, the only certainty is that the juggernaut of the genetic revolution is rapidly advancing and that in the name of medical progress animals are being victimized and exploited in new ways, while the replication of human beings is looming.

The human species is thus at a terribly difficult and complex crossroads. Whatever steps we take, it is imperative we do not leave the decisions to the scientists, anymore than we would to the theologians (or corporate-hired bioethicists for that matter), for their judgment and objectivity is less than perfect, especially for the majority who are employed by biotechnology corporations and have a vested interest in the hastening and patenting of the brave new world of biotechnology. The issues involving genetics are so important that scientific, political, and moral debate must take place squarely within the public sphere. The fate of human beings, animals, and nature hangs in the balance, thus it is imperative that the public become informed on the latest developments and biotechnology and that lively and substantive democratic debate take place concerning the crucial issues raised by the new technosciences.

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Appendix 1

NANOTECHNOLOGY, SOCIETY, AND ETHICS

Patrick Lin and Fritz Allhoff

Nanoethics, or the study of nanotechnology's ethical and social implications, is an emerging but controversial field. Outside of the industry and academia, most people are first introduced to nanotechnology through fictional works that posit scenarios - which scientists largely reject - of self-replicating "nanobots" running amok like a pandemic virus (Crichton, 2002). In the mainstream media, we are beginning to hear more reports about the risks nanotechnology poses on the environment, health and safety, with conflicting reports from within the industry.

But within the nanotechnology industry, there is a strange schizophrenia afoot. We have heard about the wonderful things that nanotechnology might enable - not just today's mundane products, such as better sports equipment or cosmetics, but the truly fantastic applications. Our imagination seems to be our only limit, as scientists and other experts predict such innovations as: toxin-eating nanobots; exoskeletons that enable us to leap walls in a single bound; affordable space travel for everyone; nano-factories that can make anything we want; and even near-immortality.

Yet nearly in the same breath, many advocates continue to deny or to ignore that nanotechnology will cause any significant disruptions or raise any serious ethical questions that we have to worry about - dismissively labeling these as "hype" (New Atlantis, 2004). But how is this possible? How can such a brave new science, one that is so full of potential that it has been called the "Next Industrial Revolution" by governments and scientists, not also impact our relationships, society, environment, economy, or even global politics in profound ways?

Let's take a step back and consider any given technology we have created: gunpowder, the printing press, the camera, the automobile, nuclear power, the computer, Prozac, Viagra, the mobile phone, the Internet. Undoubtedly, these have brought us much good, but each has also changed society in important, fundamental ways and caused new problems, such as increased pollution, urban sprawl, cyber-crimes, privacy concerns, intellectual property concerns, drug dependencies, new cases of sexually-transmitted diseases, other unintended health problems, mutually-assured destruction and much more. The point here is not that we would have been better off without these inventions. Rather, we should come to terms that our creations can have unintended or unforeseen consequences.

Many of the social problems associated with the aforementioned technologies might have been anticipated and mitigated with some forethought. This is a lesson not lost on policymakers and scientists today, for instance, in having spent millions of dollars to study the ethical implications of decoding the human genome, such as privacy and genetic discrimination concerns. The same lesson, however, apparently was lost on the commercial biotechnology industry, which recently discovered that by ignoring its ethical and social issues - specifically, the possible harm from genetically-modified foods on human health and the environment - they invited a public backlash that crippled progress and sent corporate stocks plummeting.

To be sure, no one expects ethicists, scientists, policymakers and other experts to anticipate and address all possible scenarios. It is a plain fact of the human condition that we do not and cannot know everything. We do not fault Thomas Edison, for instance, for the copyright-violating devices that his phonograph would inspire, or Henry Ford for the agonizing commutes we endure daily, or Bill Gates for the email "spam" we receive.

And when we try to make predictions about technology, we are often wrong. Consider the following infamous predictions: "This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us" (Western Union, 1876); "Who the hell wants to hear actors talk?" (H. M. Warner, Warner Brothers, 1927); "I think there is a world market for maybe five computers" (Thomas Watson, chairman of IBM, 1943); "With over 50 foreign cars already on sale here, the Japanese auto industry isn't likely to carve out a big slice of the U.S. market" (BusinessWeek, August 2, 1968); and "There is no reason anyone would want a computer in their home" (Ken Olson, founder of Digital Equipment Corp., 1977).

Clearly, it is easy to be too conservative or short-sighted in estimating the future impact of technology. The dangers associated with technology can likewise be underestimated, for instance, as was the case with asbestos, lead paint and the pesticide DDT. But this is not just a failing of our distant past. In 2006 alone, a study has suggested that mobile phones, after all our years of using them, can cause brain tumors and infertility (Hardell et al., 2006). Another study showed that computer manufacturing workers, after decades on the job, are at a much greater risk of death from cancer and other illnesses (Clapp, 2006). In the same year, the U.S. Environmental Protection Agency concluded that a key chemical (PFOA) used to make Teflon – the ubiquitous material used for the last 50 years in non-stick cookware, carpeting, clothing, food packaging and thousands of other products, and traces of which can be found in the blood of nearly everyone in the US and other developed nations – is a carcinogen (USEPA, 2006).

At the other end of the spectrum, some predictions also overestimate the role of technology, as was the case with robotic maids, flying cars, meal-in-a-pill, and the death of privacy, for instance. So it is no surprise that the impact of nanotechnology should be both understated and overhyped, and in either case, we can trust that it will have consequences that we have not even considered or imagined. However, not being certain about the future does not relieve us of any moral obligation to investigate the issues we can anticipate as being reasonable possibilities or relevant. From the rapid pace of new technologies entering our lives, we can now appreciate that such technologies will have societal implications, for better or worse. Learning from history, we also now understand that we have a responsibility to consider these scenarios in advance to mitigate any harms, if not also to maximize benefits.

Discourse into the ethical and social dimensions of nanotechnology - so-called "nanoethics" - is therefore critical to guide the development of nanotechnology. This anthology provides an introduction to many of the most urgent issues today in nanoethics, focusing on current and near-term debates.

1. What is Nanotechnology?

First, we need to be clear on what nanotechnology is before we can appreciate the ethical and social questions that arise therein. Nanotechnology is a new category of technology that involves the precise manipulation of materials at the molecular level or a scale of roughly 1 to 100 nanometers – with a nanometer equaling one-billionth of a meter – in ways that exploit novel properties that emerge at that scale. How small exactly is a billionth of a meter? As one journalist had put it, "If a nanometer were somehow magnified to appear as long as the nose on your face, then a red blood cell would appear the size of the Empire State Building, a human hair would be about two or three miles wide, one of your fingers would span the continental United States, and a normal person would be about as tall as six or seven planet Earths piled atop one another" (Keiper, 2003).

Working at the nanoscale, it turns out that ordinary materials can have extraordinary properties, about which we are still learning. At the nanoscale, quantum physics begins to play a key role in the behavior of materials, and the large surface-to-volume ratio of elements means that they are much more reactive. So, for instance, things that are brittle at the ordinary scale may possess superstrength at the nanoscale, and things that do not normally conduct electricity now might at the nanoscale, among other surprising changes to physical and chemical properties.

As a specific example of how properties change with scale, aluminum is used ubiquitously to make harmless soda cans, but in fine powder form, it can explode violently when in contact with air. But it is not only about the size: by precisely manipulating common elements at the nanoscale, scientists can fashion new materials. For example, carbon atoms bound together in a relatively-loose configuration may create coal or graphite found in pencils; in a tighter configuration, carbon makes diamonds; and an even more precise configuration, it creates carbon nanotubes, one of the strongest materials known to man, estimated to be up to 100 times stronger than steel at one-sixth the weight.

Given these new properties, nanotechnology is predicted to enable such things as: smaller, faster processing chips that enable computers to be imbedded in our clothing or even in our bodies; medical advances for dramatically less-invasive surgeries and more-targeted drug delivery; lighter, stronger materials that make transportation safer and energy-efficient (e.g., enabling us to travel farther into space); new military capabilities such as energy weapons and lighter armor; and countless other innovations. Some even predict that nanotechnology will extend our lifespan by hundreds of years or more by enabling cellular repair, which might slow, halt, or reverse the aging process (Freitas, 2004). And because nanotechnology may enable us to manipulate individual atoms - the very building blocks of nature - some have predicted that we will be able to create virtually anything we want in the future (Drexler, 1986).

Today, however, research is still continuing on the basic science, so we are years and possibly decades away from most of the fantastic nanotechnology products that have been predicted, if they ever come to fruition at all. Nevertheless, companies are beginning to productize more of their research to create commercially-viable applications based on nanomaterials. These nanotechnology products are quickly entering the marketplace today, from stain-resistant pants to scratch-resistant paint to better sports equipment to more effective cosmetics and sunblock.

In fact, Procter & Gamble, as one example of a leading consumer goods company, announced in 2006 that it is looking to incorporate nanotechnology into its products (O'Donnell, 2006). Other notable companies made similar statements recently as well, such as BASF's plan to invest US$221 million in nanotechnology research and development over just the next three years (James, 2006).

2. Is Nanotechnology a Distinct Discipline?

Before we investigate the myriad issues in nanoethics as covered in this anthology, we must first address a persistent meta-controversy surrounding the status of nanotechnology itself, which casts questions about the legitimacy of nanoethics as its own discipline.

Despite massive spending in nanotechnology by corporations and countries - the US government alone is expected to invest over US$1.2 billion in 2007 through its National Nanotechnology Initiative (NNI) - there is still a debate over whether "nanotechnology" is an independent or new science, so unique from other fields that it should require or deserve its own category or moniker. Some have complained that nanotechnology is not distinct from other sciences - or at least its boundaries might be somewhat hazy - and therefore its ethics must be equally ill-defined. Others argue further that nanoethics is not an interesting or distinct field because it does not raise any new questions that are not already considered by, say, bioethics or computer ethics. In the remaining part of this introduction, we will argue that nanoethics should be afforded legitimacy.

At first glance, this controversy seems strange, given that so much is being invested in nanotechnology worldwide. If nanotechnology were not a distinct science, then why does it command so much attention and money? Many people, however, believe nanotechnology to be merely a convergence or amalgamation of several existing disciplines, such as chemistry, biology, physics, material science, engineering, information technology and so on; claims like this have at least some truth.

As an example of biology inspiring engineering, scientists are creating artificial noses with nano-sized sensors which can accurately "sniff" out smells that are otherwise imperceptible to humans (Nanomix Inc., 2006). Similar work has been done to create artificial compound eyes (Jeong, 2006), borrowing from nature's design of insect eyes, as well as artificial skin (Maheshwari and Saraf, 2006) using nanomaterials to mimic the sensitivity of touch. And entire research centers have been created to explore this rich field, including Georgia Institute of Technology's Center for Biologically Inspired Designs (CBID) and University of California at Berkeley's Center for Interdisciplinary Bio-Inspiration in Education and Research (CIBER).

But does drawing from other scientific areas preclude nanotechnology from being a field in its own right? Consider the similar and ongoing debate in philosophy of science whether chemistry, biology and other established sciences can be reduced to simply physics. One line of thought is that these other fields operate they way they do given the laws of physics that govern how atoms, molecules and their dependent structures interact with each other and the world. But no matter which side of the debate we take here, no one on either side actually suggests that chemistry and biology, for example, do not constitute their own disciplines; so it would be inconsistent to insist that nanotechnology - even if it substantially borrows from other fields - cannot be meaningfully discussed or investigated as a field of its own. As with these other scientific fields, nanotechnology seems to bring something unique to the discussion that merits recognition as its own field; or in other words, it is greater than the sum of its parts. At the least, it appears to be the first to integrate otherwise-distinct fields into this one area.

Another source of the controversy about nanotechnology's ontological status comes from various opinions on when the field was first created. Many point to Richard Feynman in 1959 as the founding father of nanotechnology; others to Norio Taniguchi in 1974; and sill others to K. Eric Drexler in 1986. But as the following statement from physicist Richard A. L. Jones (2006) indicates, a growing sentiment in the field points to a much more recent, and unlikely, person:

> Perhaps a better candidate to be considered nanotechnology's father figure is President Clinton, whose support of the USA's National Nanotechnology Initiative converted overnight many industrious physicists, chemists and materials scientists into nanotechnologists. In this cynical (though popular) view, the idea of nanotechnology did not emerge naturally from its parent disciplines, but was imposed on the scientific community from outside.

So depending on whom one speaks to, nanotechnology might have been first established anywhere from 1959 to 2000. And if former U.S. president Bill Clinton can plausibly claim the title "father of nanotechnology", then it is no wonder that many scientists and other experts regard nanotechnology as merely a political construct or a marketing buzzword invented to resuscitate old disciplines that appear to belosing ground, particularly in the U.S. where the decline of science graduates has been well documented.

3. What is the Status of Nanoethics?

Whether or not nanotechnology is a fabricated area of study and indistinct from other scientific fields, which is not a question we intend or need to answer here, we can already now understand some of the controversy surrounding the status of nanoethics: if nanotechnology is just a fancy term for a range of other fields, then ethical and social questions arising from nanotechnology would seem to be the same kind of questions already raised in these other fields. Indeed, one critic, Suren Holm (2005), asks:

> It is difficult to specify exactly what could make an area of technology so special that it needs its own ethics, but a minimal requirement must be that it either raises ethical issues that are not raised by other kinds of technologies, or that it raises ethical issues of a different (i.e., larger) magnitude than other technologies. Is this the case for nanotechnology?

Philip Ball, science writer for Nature, elaborates on this point:

> Questions about safety, equity, military involvement and openness are ones that pertain to many other areas of science and technology [and not just nanotechnology]. It would be a grave and possibly dangerous distortion if nanotechnology were to come to be seen as a discipline that raises unprecedented ethical and moral issues. In this respect, I think it genuinely does differ from some aspects of biotechnological research, which broach entirely new moral questions.

These are fair and forgivable concerns, and current research in nanoethics might even support this position. For instance, in shrinking down devices, nanotechnology is expected to create a new class of surveillance devices that are virtually invisible and undetectable, thereby raising privacy questions; however, according to critics, these questions do not appear to be new but simply an extension of the current debate about privacy. Nanotechnology is also predicted to play a critical role in developing human-enhancing technologies, such as cybernetic body parts or an exoskeleton that gives us superhuman strength or infrared vision; however, society has already been discussing the ethics of such technologies with respect to biotechnology and cognitive sciences. In the more distant future, some people envision nanotechnology's role in extending the human lifespan to the point of near-immortality; but the question of whether we want or should live longer, or forever – as well as its political, economic and social impacts - does not seem dependent on nanotechnology per se.

On the other hand, some issues are emerging that appear unique to nanotechnology, namely the new environmental, health and safety (EHS) risks arising nanomaterials. For instance, research studies suggest that some nanoparticles are directly harmful to animals, and because they can be taken up by cells, they might enter our food chain to unknown effects on human health (Chithrani et al., 2006). Other research asks whether carbon nanotubes will be the next asbestos, since both have the same whisker-like shape that makes it so difficult to purge from our lungs if inhaled (Gogotsi, 2003). And the flip side of creating super-strong materials such as carbon nanotubes is their fate at the end of a product life-cycle: will these materials persist indefinitely in our landfills, as is the case with Styrofoam or nuclear waste? (Colvin and Wiesner, 2002)

One new ethical issue is perhaps not enough to legitimize the independence of nanoethics. And in fact, we could perhaps reduce even this apparently-unique issue to belong to another discipline, such as engineering or environmental ethics that questions the wisdom of creating products that do not decompose. But there are other good reasons for believing that nanoethics deserves our attention, especially if we believe that nanotechnology itself is a distinct field.

First, nanoethics also commands a significant amount of attention and money, though far less than the amount poured into nanotechnology. In the U.S., the NNI currently sets aside approximately $43 million for the "identification and quantification of the broad implications of nanotechnology for society, including social, economic, workforce, educational, ethical, and legal implications" (USNNI). So it would certainly be strange that there would be so much invested by various government agencies, universities, publishers and other organizations globally, if nanoethics were not important as its own field. Of course, there is a possibility that all these organizations and scholars have been fooled because nanotechnology and its ethics allegedly do not exist, but that appears more unlikely than correctly and reasonably identifying nanotechnology as a meaningful area of its own. And at any rate, the point is perhaps already moot given that nanoethics and nanotechnology have taken life of their own.

Second, it is unclear why we should accept the litmus test that, to be counted as a new discipline in its own right, nanoethics must either raise new or larger ethical issues than already raised by previous technologies. Looking again at chemistry, for example, whether or not we can properly categorize it as a subset of physics (because chemistry arguably does not raise new questions that cannot be answered by physics), there is no existential dilemma about its status as a legitimate category; no one is proposing to do away with the name or reorganize the university chemistry lab under the physics department. Therefore, it is unclear why such a dilemma would exist with nanoethics, even if nanoethics can be wholly contained within another field or set of fields.

Third, to the extent that nanotechnology is a convergence of many disciplines in the first place, it should be no surprise that nanoethics is a convergence of many ethical areas as well. So even if a new area of ethics requires raising new or larger issues, that standard may no longer apply with the discovery or creation of nanotechnology. Rather, nanotechnology might uniquely draw from other disciplines like no other discipline before it.

Rather than an argument that nanotechnology is not a distinct discipline because it does not truly break new ground, nanotechnology seems to represent a new pinnacle in our understanding about the world. We are finally able to integrate our learning from a wide range of fields (e.g., physics, chemistry, biology, engineering, and others) to create profoundly useful applications which can be categorized under the moniker of "nanotechnology." So just as, for example, architecture can be regarded as a convergence of aesthetic design and engineering, so too can nanotechnology and nanoethics be rightfully acknowledged even if they are a convergence of other fields.

Again, the whole of nanotechnology is arguably greater than the sum of its parts, because of the new synergies or interplay between the various parts.

Fourth, nanoethics does seem to raise new ethical issues insofar as it adds a new dimension or "flavour" to current ethical debates. For instance, though privacy may be a relatively old debate, the possibility of creating near-invisible and undetectable devices did not meaningfully exist prior to nanotechnology; so nanotechnology brings a new urgency and reality to the issue of privacy. Further, nanotechnology may help shift the privacy debate in an entirely new direction: whereas worries about unauthorized or unwanted surveillance have traditionally focused on a few agencies, notably governmental organizations, the possibility of cheap, ubiquitous tracking devices "decentralizes" surveillance and changes the terms of the debate.

Nanotechnology likewise is putting a new spotlight and elevating other ethical issues, such as related to human enhancement or longevity. Even something as apparently tangential as the ethics of space exploration and settlements – or space ethics – now overlaps with nanoethics, because only with nanotechnology does the possibility of extended space flights and terraforming (i.e., the ability to create a hospitable atmosphere and environment on another planet or moon) become plausible.

Finally, it is not even clear that the question of whether nanotechnology and nanoethics are disciplines in their own right has any real consequence to our discussion here. That is, even if we agree that both are not distinct disciplines, it does not follow that nanoscientists and nanoethicists should stop conducting their work, nor does it follow that the massive levels of funding for both nanotechnology and its social impact should be diminished. Rather, it seems that, even if nanotechnology and nanoethics were each comprised of overlapping, established areas in science and philosophy, they nonetheless are comprised of something. Furthermore, it is this constitution that legitimizes the disciplines, not their entitlement to necessarily proprietary issues which continue to exist even if the associative terms of "nanotechnology" and "nanoethics" are successfully challenged.

In other words, the debate seems to be more semantic than substantive; this debate is not an obstacle to intelligently discussing either nanotechnology or nanoethics. Even if we agree that both borrow substantially from other areas and therefore should not be considered as distinct disciplines in their own right, we can nevertheless stipulate that we mean "nanotechnology" to be simply short-hand or abbreviations of some longer and unwieldy (yet technically-accurate) descriptors such as, for instance, "the development, characterization, and functionalization of materials based on nanoscale research in chemistry, physics, biology, engineering, materials science, and so on." And perhaps "nanoethics" means something like "the ethical, social, environmental, medical, political, economic, legal issues, and so on, arising from nanotechnology (as defined by the preceding)" or however we want to precisely define these terms. Regardless, the point is that these terms can be stipulated as is linguistically useful to capture actual investigation in the world; the conceptual independence of those investigations does not deprecate the enterprise.

4. Issues in Nanoethics

If nanoethics is a distinct discipline – or even if it is not, but we still understand what the term describes – then what are its issues? Again, controversy surrounds even this question. If we are conservative and only acknowledge those issues that will likely or possibly arise from current lines of research in nanotechnology – which is primarily focused on the discovery and applications of new nanomaterials – then nanoethics certainly covers some of the issues mentioned above: EHS impacts, privacy, human enhancement as well as global security (since the military is a major driver of nanotechnology research to such a degree that some fear a new arms race) (Lawlor, 2005). Other relevant issues may include research ethics (if some research seems to dangerous to publish or pursue), intellectual property (if today's patent-grab and processes stifle innovation), and humanitarianism (why we are not doing more to solve poverty, hunger, energy, clean water and other problems through nanotechnology).

But more imaginative people, such as Drexler, postulate a more advanced form of nanotechnology in our future – sometimes called "molecular manufacturing" - by which we can position individual molecules with exact precision. The difference between how we create nanomaterials today (e.g., carbon nanotubes) with precisely-positioned molecules, and molecular manufacturing is the difference between engineering and chemistry. Carbon nanotubes rely on bulk chemical processes and reactions at high temperatures to create the desired configuration of carbon atoms, which is similar in principle to the usual chemistry experiments in which various elements and compounds are thrown together in bulk and shaken up to predictably create a batch of new compounds. In contrast, molecular manufacturing is envisioned to be more like a construction job, grabbing single atoms and deliberately attaching them to others to form the desired structure. This high degree of precision, without messy chemical reactions, would in theory enable us to create practically any possible object.

This line of thought is instantiated by a detailed speculative design for a "nanofactory" that might be a portable or desktop device - a black box of sorts – that can create virtually any object we want, from cakes to computers. To oversimplify things, raw materials, say dirt and water, might go in one end, and a raw steak or perhaps an unmanned fighter jet might come out the other. While this may sound like science fiction, the theory behind it seems sound: if we can precisely manipulate molecules, and physical objects are only made up of molecules, then why wouldn't we be able create any physical object we want?

If this still sounds far-fetched, consider the similarities with today's 3-D printers that can print out plastic or ceramic objects one thin layer at a time. No longer limited to producing only manufacturing prototypes and machine parts, 3-D printers recently broke new ground in printing out fully functional and fashionable footwear, among an expanding and impressive array of print-on-demand products (Engineering & Manufacturing Services Inc., 2006). The nanofactory operates by the same concept, except with much more precision and a mix of different materials.

So if advance nanotechnology is in our possible future, then it raises truly unique and serious questions; following the litmus test considered earlier, it may strongly support nanoethics as a legitimate discipline. Molecular manufacturing appears to have the potential to wreak havoc on our economic system where millions might lose their jobs overnight in the manufacturing and other industries and perhaps eliminating the need for global trade. If people and terrorists can easily create weapons with personal nanofactories, that may threaten global security and the lives of millions or billions of others. Some of the more fantastic issues are also related to advanced forms of nanotechnology, if not directly to molecular manufacturing, such as longevity or immortality, space settlements and artificial intelligence.

However, because these issues are tied to advanced forms of nanotechnology - the plausibility or likelihood of which is contentious among mainstream scientists - critics may believe that it is inappropriate or well premature to consider such issues now. But we do not need to resolve that question here in order to take seriously the ethical and social issues advanced nanotechnology might raise. Even if advanced nanotechnology is a remote possibility, its scenarios appear so disruptive that they merit consideration. A simple cost-benefit analysis might justify spending $5 million over the next decade to study and perhaps mitigate a scenario that has a 1% possibility of causing $1 billion of economic disruption, which has an expected negative utility or value of $10 million. (These figures are purely hypothetical but appear to be in a plausible range.)

As an analogy, if decoding the human genome had just a small likelihood of, say, leading to employment or insurance discrimination based on a person's genetic predisposition, we would then still expect that scenario to be important enough to warrant an investigation; and in fact, such ethics research has been ongoing in the last decade Or more abstractly, if a political course had even a bare possibility to leading to a devastating war, costing the lives of millions, it seems that we are morally obligated to seriously consider that possibility, no matter how remote.

With nanotechnology, so much is still unknown that scientists are really not in a position to accurately forecast what is likely or not and by when. Some believe molecular manufacturing is inevitable; others disagree. But again, if history is any guide, most of our mid- and long-terms predictions about technology will be overly optimistic or pessimistic. Many things we have today were once believed to be impossible or impractical - such as gas streetlights, residential electricity, telephones, highways, radio, airplanes, rockets and even today's ubiquitous personal computer - so perhaps the prudent course is to treat most of these possibilities as reasonable until proven otherwise.

Even near-term challenges in technology - such as how to shrink the smallest computer processor even further – seem difficult if not intractable to us right now, but somehow we find a way to sustain Moore's Law, which posits a doubling of processing power every 18 months and which some predict will soon fail to hold (Zhirnov et al., 2003). Technology is moving rapidly indeed and may be limited now only by our imagination, so it is not implausible to think any technical challenges associated with molecular manufacturing might be eventually solved.

Indeed, scientists have recently announced creating a blueprint, and then a working prototype, of an "invisibility cloak" – essentially a heavy blanket created with nanomaterials that can bend, instead of reflect or diffuse, light and other electromagnetic waves around the object cloaked, just as water might flow around a rock in the middle of a stream (Pendry et al., 2006). (This, too, seems to give rise to ethical issues associated only with nanotechnology, namely privacy and security, if we are still interested in identifying unique issues.) But as late as 2006, such innovations would have been thought as merely science fiction, consigned to fantasy worlds such as Harry Potter's. Again, throughout history and even now, ideas that have been dismissed as unworkable somehow become reality, despite their technical challenges, so it is not irrational to treat molecular manufacturing, space settlements and so on as a real possibility absent compelling evidence to the contrary.

Furthermore, no matter how speculative some of these scenarios seem to be, they provide a useful platform to test our moral principles as at least "thought experiments", which is a commonly-accepted practice in ethics. For instance, no one thinks that anyone would plausibly be kidnapped and surgically connected to a famous violinist – the premature detachment of whom would lead to the violinist's death - but this hypothetical example isolates and tests out intuitions in Judith Jarvis Thomson's discussion about the moral permissibility of abortion (Thomson, 1971).

Also, few actually question the wisdom of sending spiders into outer space on the grounds that spiders do not exist and may never exist in space (unless we introduce them into space); yet this sort of experiment is useful to study the relationship between gravity and a spider's ability to orient itself and spin webs by isolating gravity as a variable. As it applies to nanotechnology, even if cybernetic people never exist, the possibility of human enhancement provides a platform, or thought-experiment, to explore intuitions related to human dignity, personal identity and other concepts.

Given all this controversy, it should also be no surprise that the questions in nanoethics seem ill-defined as compared to, say, ethical questions in decoding the human genome, as some critics have pointed out (Harris, 2006). Nanotechnology itself is fractured into different approaches or visions, each of which raises it own questions; so, until there is a consensus on what nanotechnology is and will be, it will be difficult to gain a consensus on a plausible set of issues for nanoethics. Moreover, the overlap of nanotechnology with other disciplines - and the overlap of nanoethics with bioethics and other areas - contributes to this challenge

Allhoff F, Lin P. Nanotechnology, Society, and Ethics. In: Allhoff F, Lin P, editors. Nanotechnology and society: Current and emerging ethical issues. New York, NY: Springer; 2008. P. xxi – xxxiv. Available from: files.allhoff.org/research/ S.00d.Lin_&_Allhoff.pdf

APPENDIX 2

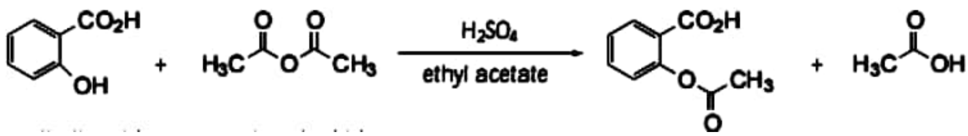
SCIENTIFIC WRITING SAMPLES

SAMPLE **LABORATORY NOTEBOOK**

EXP. NUMBER	EXPERIMENT/ SUBJECT		DATE	
1	*Organic Chem 2 Lab*		*2/29/13*	*1*
NAME		LOCKER NO.	COURSE AND SECTION NO.	
John Doe (TA: Gregg N. Yard)		*55*	*Chem 3341-111*	

The Preparation of Aspirin

The purpose of this experiment is to synthesize aspirin (acetyl salicylic acid) from salicylic acid and acetic anhydride.



salicylic acid 2g (0.014 mole)	*acetic anhydride 5mL (0.05 mole)*		*acetyl salicylic acid*	*acetic acid*

The limiting reagent is salicylic acid. The theoretical yield of acetyl salicylic acid is 2.52 g.

*Physical Data**	*MW*	*mp*	*bp*	*density*	*solubility*	*hazards*
salicylic acid	*138*	*157-9*	_	_	*al, eth, ace*	*toxic*
acetyl salicylic acid	*180*	*135-6*	_	_	*al, eth, chl*	*irritant*
acetic anhydride	*102*	_	*138*	*1.08*	_	*corrosive,*
acetic acid	*60*	_	*117-8*	*1.049*	_	*lachrymator*
sulfuric acid	*98*	_	_	*1.84*	_	*corrosive*
ethyl acetate	*88*	_	*77*	*0.90*	_	*corrosive flammable*

**Data from the CRC, 70^{th} ed.*

Calculations:
2 g salicylic acid (1 mole/138 g) = 0.014 moles
5 mL acetic anhydride (1.08 g/mL) = 5.4 g then,
5.4 g (1 mole/102 g) = 0.05 moles
thus salicylic acid is present in the lesser molar amount and is the limiting reagent therefore the theoretical yield of acetyl salicylic acid is 0.014 moles, or 0.014 moles (180 g/mole) = 2.52 g

SIGNATURE	DATE
John Doe	*2/29/13*

EXP. NUMBER	EXPERIMENT/ SUBJECT		DATE	
1	*Organic Chem 2 Lab*		*2/29/13*	*2*
NAME		LOCKER NO.	COURSE AND SECTION NO.	
John Doe (TA: Gregg N. Yard)		*55*	*Chem 3341-111*	

<u>The Preparation of Aspirin (con't)</u>

<u>Procedure</u>

From: Experiments for Organic Chemistry, Chem 3341, Spring 2000, pp. 20-25

1) Mix salicylic acid and acetic anhydride in a 125 mL Erlenmeyer flask, add 5 drops H_2SO_4.

2) Heat on steam bath for 10 min, then cool.

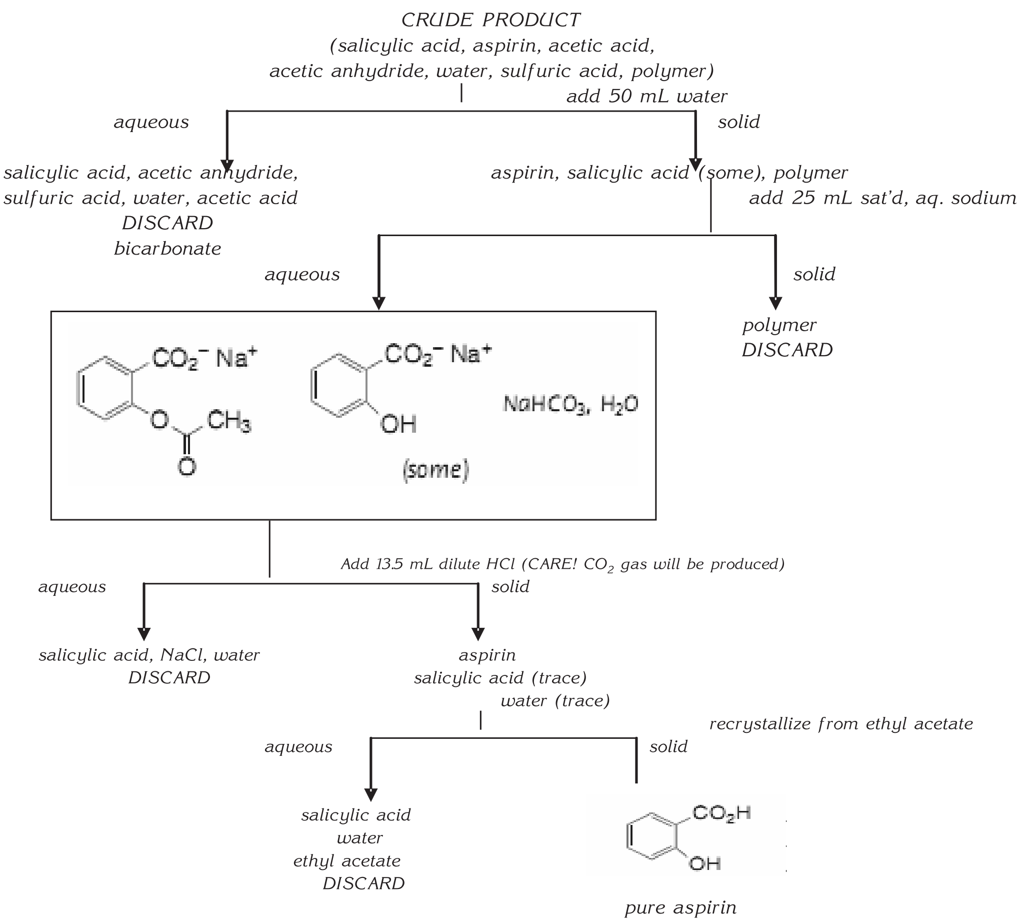
3) Add 50 mL water and cool on ice.

4) Collect product by vacuum filtration.

5) Air dry the crude product crystals and determine a crude yield.

6) Purify as in the flow chart ~~below~~ on the next page.

flow chart for purification of crude product.



SIGNATURE	DATE
John Doe	*2/29/13*

Exp. number *1*	Experiment/ subject *Organic Chem 2 Lab*		Date *2/29/13*	*3*
Name *John Doe (TA: Gregg N. Yard)*		Locker no. *55*	Course and section no. *Chem 3341-111*	

The Preparation of Aspirin (con't)

Data and Observations

wt of salicylic acid + paper: ~~2.30 g~~ 2.43 g
wt of paper: 0.43 g
salicylic acid: 2.00 g

1) On mixing, it took a few minutes for everything to go into solution. The addition of sulfuric acid caused some fizzing.
2) Heated for about 15 min instead of the planned 10 min.
3) After adding the water and cooling, no crystals appeared. On the suggestion of my TA, I scratched the flask with a glass rod, chilled it on ice for 10 more min, and finally a lot of slightly tan crystals appeared.
4) Quite a lot of solid, lightly tan, was collected on the filter paper
5) Let dry for 10 min.

crude product + watchglass: 32.02 g
watchglass: 30.10 g
crude product: 1.92 g
% yield of crude product: 1.92 g/2.52 g = 76%
*mp = 125-129 *

6) When I followed the scheme in the flow chart for purification of the crude product, I noticed that when I added the sodium bicarbonate, the product turned yellow. I suspected a contaminated (dirty) beaker. So, I treated the mixture with Norite pellets. A clear solution resulted. The purification scheme was followed without mishap through the recrystallization from ethyl acetate.

crude product + watchglass: 31.80 g
watchglass: 30.10 g
crude product: 1.70 g
% yield of crude product: 1.70 g/2.52 g = 67%
mp = 133-135

Signature *John Doe*	Date *2/29/13*

EXP. NUMBER	EXPERIMENT/ SUBJECT		DATE	4
1	Organic Chem 2 Lab		2/29/13	
NAME		LOCKER NO.	COURSE AND SECTION NO.	
John Doe (TA: Gregg N. Yard)		55	Chem 3341-111	

The Preparation of Aspirin (con't)

Conclusion

The yield of purified aspirin was 1.70 g or 67% yield. Although an acceptable value, future experimenters could take steps to better the yield, perhaps by running the reaction for longer than 15 min to encourage more product formation, or by more carefully rinsing the flask when transferring crystals. Also, some product may have been lost by the Norite step (added to remove the colored contaminant). I'd suggest carefully checking the cleanliness of all glassware before beginning the purification step to eliminate the need for this step and thus to improve yield.

The wide range and low value of the mp of the crude product indicates that before recrystallization, the aspirin was not very pure. After recrystallization, the small mp range of aspirin (133-135) indicates a pure compound. This value correlates well with the literature value (135-136) for the mp of aspirin. From this data, it is likely that the compound isolated is aspirin, although further tests such as mixed melting points and spectroscopic data would be required to prove that it is aspirin.°

SIGNATURE	DATE
John Doe	2/29/13

SAMPLE **RESEARCH PAPER 1**

Werner K. 2012, in A. Manchado, L. Stanghellini, & D. Schunberner, (eds.), *Planetary Nebulae: An Eye to the Future, Proc*. IAU Symp. No. 283

Central stars of planetary nebulae: The white dwarf connection

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Abstract. This paper is focused on the transition phase between central stars and white dwarfs, i.e. objects in the effective temperature range 100000-200000 K. We confine our review to hydrogen-deficient stars because the common H-rich objects are subject of the paper by Ziegler et al.in these proceedings. We address the claimed iron-deficiency in PG1159 stars and [WC] central stars. The discovery of new Ne VII and Ne VIII lines in PG1159 stars suggests that the identification of O VII and O VIII lines that are used for spectral classification of [WCE] stars is wrong. We then present evidence for two distinct post-AGB evolutionary sequences for H-deficient stars based on abundance analyses of the He-dominated O(He) stars and the hot DO white dwarf KPD 0005+5106. Finally, we report on evidence for an H-deficient post-super AGB evolution sequence represented by the hottest known, carbon/ oxygen-atmosphere white dwarf H 1504+65 and the recently discovered carbon-atmosphere “hot DQ” white dwarfs.

Keywords: stars: abundances, stars: AGB and post-AGB, stars: atmospheres, stars: early-type, stars: evolution, white dwarfs, planetary nebulae: general, ultraviolet: stars.

1. Introduction

M’endez et al. (1986) have introduced the O(He) and O(C) designations (besides others) to classify the optical spectra of hot hydrogen-deficient central stars. The O(He) stars have almost pure He II absorption line spectra whereas the O(C) stars additionally show strong lines from C IV and sometimes O VI. While the O (He) designation is still in use, the O (C)stars are today more commonly called PG 1159 stars after their prototype PG 1159–035.They also comprise some of the stars that were previously termed “O VI” central stars. PG 1159 stars are thought to be the progeny of the Wolf-Rayet type central stars (spectral type [WC]), while future evolution will turn them into non-DA white dwarfs. In fact, the picture is a bit more complicated, because a few PG 1159 stars show traces of H and these should become DA white dwarfs. The existence of remnant hydrogen can be explained by a special variant of the late He-shell flash (or born-again star) scenario, which is invoked to be the origin of the H-deficient chemistry.

PG1159 and [WC] stars are particularly useful to test AGB star nucleosynthesis models, because the late He-shell flash that the stars have suffered laid bare the intershell matter between the H and He burning shells. The observed surface abundances can be directly compared to model predictions for the chemical composition of the AGB star intershell region, where nucleosynthesis of heavy elements proceeds. In this context, one particular problem is the unexpectedly strong iron deficiency claimed for PG 1159 and [WC] stars. This is addressed in Sect. 2.1. We will also highlight some results on abundance determinations of other metals in PG 1159 stars (Sect. 2.2). During the course of neon line identifications and abundance determinations it was discovered that the identification of ultrahigh-ionization spectral lines of oxygen - that are commonly used to classify early-type [WC] stars - is wrong (Sect. 2.3).

While we think that the O(C) (thus PG1159) stars are part of the sequence [WC] → PG1159 → non-DA WD, the evolutionary context of O(He) stars is less clear. They are not explained by the late He-shell flash scenario and there is additional evidence that they indeed belong to a distinct H-deficient post-AGB sequence (see Sect. 3).

Finally, in Sect. 4 we dwell on rather exotic white dwarfs with atmospheres devoid of H and He, which might be the progeny of super-post AGB stars, i.e. red giants that burned carbon.

2. PG1159 and [WC] stars

Recent comprehensive reviews on stellar and atmospheric parameters of [WC] and PG1159 stars can be found in Crowther (2008) and Werner etal. (2008), respectively. The stellar evolution context was summarized by Werner & Herwig (2006).

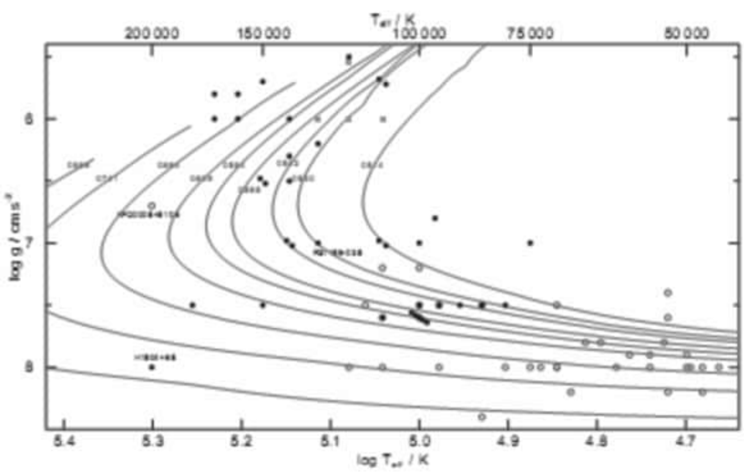

Figure 1. Location of PG1159 stars (filled circles), DO white dwarfs (open circles), and O(He) stars (squares) in the g-T_{eff} diagram. Atmospheric parameters for PG1159s and DOs were taken from compilations in Werner & Herwig (2006) and Althaus et al. (2009), respectively, with some improvements according to more recent work. O(He) parameters are from Reindl et al. (these proceedings). Evolutionary tracks for non-DA white dwarfs are from Althaus et al. (2009) and they are labeled with the WD mass in M©.

In the HRD, [WC] stars are evolving along the constant-luminosity, horizontal part of post-AGB tracks towards high effective temperature. They cover the range of $T_{ef} \approx 20\ 000K$-150000K. Along the way, the stars shrink such that their surface gravity increases from roughly log g = 3 to 6. With decreasing mass-loss rate, the stars turn into PG1159 stars. The latter populate the region where the stars evolve around the "knee" of the tracks, reaching the maximum effective temperature and subsequently cooling along the WD sequence. Their gravity increases from log g = 5.5 to 8. The hottest PG1159 stars have T_{ef} near 200 000 K, while the most evolved ones are observed at about T_{ef} = 75 000 K. At this region, the stars turn into He-rich white dwarfs (or H-rich in the case some trace H was left) because of gravitational settling of heavy elements. Figure 1 shows the position of all analyzed PG1159 stars, O(He) stars, and hot non-DA white dwarfs (spectral type DO) in the g-T_{eff} diagram. Note that roughly every other PG1159 star has no associated PN, probably because of its advanced evolutionary state.

The most abundant elements in [WC] and PG1159 atmospheres are He, C, and O. Their relative abundance varies strongly from star to star. For example, a typical mass ratio is displayed by the PG1159 prototype: He/C/O = 33/48/17.

As already mentioned in the introduction, abundances of other metals are interesting to compare with nucleosynthesis models. In the next subsections, we concentrate on some specific highlights and problems, focusing on PG1159 stars.

2.1. Are PG1159 and [WC] stars iron deficient?

Based on the non-detection of iron lines in any PG1159 star, an iron deficiency up to about one dex was claimed for a number of objects (e.g. Jahn etal. 2007). This is unexplained by stellar models, because they predict an only marginal Fe reduction by 10% due to neutron captures. An unexpectedly strong Fe depletion was also reported for [WC] stars (e.g. Crowther et al. 1998).

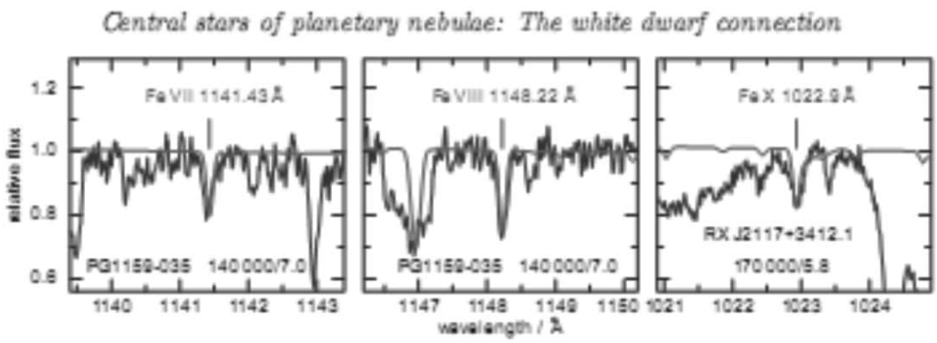

Figure 2. High-ionization iron lines in PG1159 stars. Left two panels: Fe VII and Fe VIII lines in the PG1159 prototype. Right: Fe x line in the central star RX J2117+3412.1. Numbers in panels denote T_{eff} and log g of the overplotted model profiles. The Fe abundance in the models is solar.

For the PG1159 stars this problem could be resolved recently by the discovery of Fe VIII and Fe x lines (Werner et al. 2010, 2011; Fig. 2) in eight of the hottest objects. The derived iron abundances are solar, being in line with stellar models within the analysis error limits. The solar iron abundance in one particular object (PG 1424+535) is consistent with its solar argon abundance (Werner et al. 2007). Argon is an independent metalicity indicator because its abundance remains unchanged in AGB star nucleosynthesis (see, e.g, Lugaro in these proceedings).

In the case of [WC] stars the problem remains. In a first attempt to model Fe VIII and Fe x lines in a [WC], Keller et al. (2011 and these proceedings) arrive at a significant iron deficiency (down to 0.3 solar) for the [WCE] NGC6905. All the more astonishing is their concurrent result of a ten times solar argon abundance.

We note that the newly discovered Fe VIII lines are also present in many H-rich central stars and DO white dwarfs (Werner et al. 2011) and together with Fe VII lines they serve as a new sensitive temperature diagnostics (Ziegler et al. and Mahsereci et al. in these proceedings).

2.2. Other trace metals in PG1159 stars: N, F, Ne, Si, P, S, Ar

Far-UV spectroscopy with FUSE augmented by UV spectroscopy with HST was seminal for first-time detection of particular elements and ionization stages in PG1159 stars. Besides iron (Fe VII, Fe VIII, Fe X), the elements fluorine (F V, F VI; left panel of Fig. 3), phosphorus (P V), neon (Ne VI - VIII, Fig. 4), and argon (Ar VII; right panel of Fig. 3) were identified for the first time. From silicon, which is usually detected through its Si IV resonance doublet, very high ionization stages were discovered (Si V- VII).

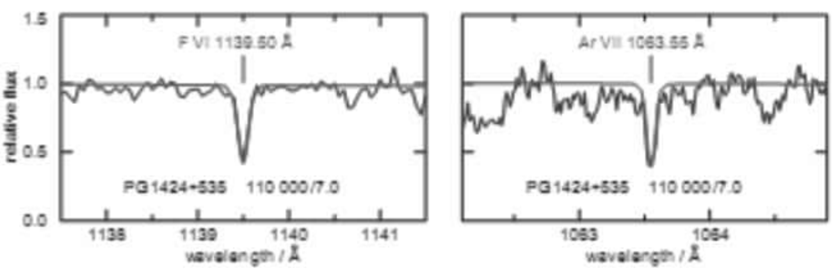

Figure 3. Fluorine line (left panel) and argon line (right panel) in the PG1159 star PG1424+535. The fluorine and argon abundances in the overplotted model are 200 times solar and solar, respectively.

Most trace metal abundances in PG1159 stars are consistent with predictions from nucleosynthesis models. For example, extreme fluorine abundances were determined in some stars (up to 200 times solar), while argon is solar. After the iron abundance problem was solved, the largest remaining discrepancy is for sulfur. In four out of five stars, we found unexpectedly strong depletions down to about 0.1 times solar or less (e.g. Jahn et al. 2007). It is remarkable, that such a sulfur anomaly is also encountered at abundance analyses of PNe (Henry et al. 2006).

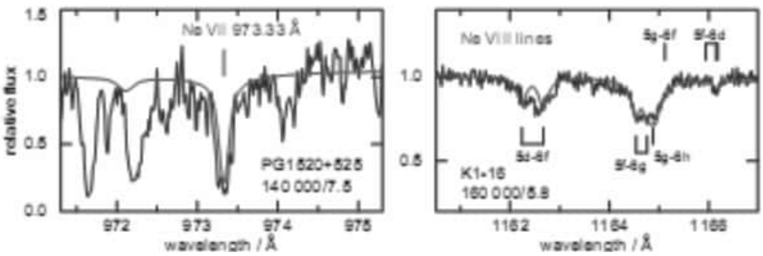

Figure 4. Highly ionized neon lines in PG1159-type central stars.
Left: Ne VII A 973.3 A in PG1520+525. Right: Ne VIII lines in K 1-16.
The neon abundance in the overplotted models is 2% by mass.

The nitrogen abundance is an important marker for the event leading to hydrogen-deficiency in PG1159 and [WC] stars. The absence (less than 0.1%, by mass) or presence (few %) of N is a reliable indicator of a late or very late thermal pulse (i.e. final pulse occurred in H-burning post-AGB state or WD cooling phase, respectively).

Neon deserves special attention. Its observed abundance is 2% (i.e. ≈15 times solar), in agreement with expectations from stellar models. During evolution, all CNO is mostly transformed into ^{14}N, which is subsequently transformed to ^{22}Ne by a captures. The discovery of neon by the identification of Ne VII and Ne VIII in U V spectra and in the optical wavelength region led to the conclusion that previous identifications of ultrahigh-ionization lines in WR stars (Pop. I and II) and in PG1159 stars must be revised.

2.3. Neon vs. oxygen: wrong identification of [WC] spectral classification lines

In order to classify the hottest [WR] stars, in particular the [WO] (which are a continuation of [WC] to higher effective temperatures), line ratios of O VI /O VII /O VIII are used (Acker & Neiner 2003). Lines from O VII and O VIII are called “ultrahigh ionization” lines (Barlow et al. 1980), because temperatures of the order 10^6 K are required to excite the respective energy levels. These are, however, not attained in the atmospheres unless e.g. shocks are invoked.

We have shown that the O VII and O VIII line identifications are probably wrong (Werner et al. 2007). All features can be ascribed to Ne VII and Ne VIII lines, respectively. This identification is much more natural because the neon lines are excited ordinarily in hot star atmospheres without invoking shocks, because and neon is an abundant element in [WC] and PG1159 stars. As a consequence, the putative O VI/O VII line ratios for example are in fact ratios of O VI to Ne VII lines. The current spectral classification scheme is therefore affected by the O/Ne abundance in the star and not only by the temperature.

Table 1. Old ultrahigh ionization line identifications and revised identifications.

Wavelength (A) Ultrahigh-ionization identification New identification				
1932	O VIII	n = 7 → 8	Ne VIII	n = 7 → 8
2977	O VIII	n = 6 → 7	Ne VIII	n = 6 → 7
3893	O VII	n = 7 → 8	Ne VII	$3p^3P^o$ $3d^3D$
			plus Ne VII	n = 7 → 8
4340	O VIII	n = 8 → 9	Ne VIII	n = 8 → 9
4500	C VI	n = 8 → 10	O VI	n = 8 → 10
4555	O VII	n = 9 → 11	Ne VII	n = 9 → 11
4945	C V	n = 6 → 7	N V	n = 6 → 7
5290	C VI	n = 7 → 8	O VI	n = 7 → 8
5665	O VII	n = 8 → 9	Ne VII	n = 8 → 9
6068	O VIII	n = 9 → 10	Ne VIII	n = 9 → 10

Other features that are commonly ascribed to ultrahigh ionization lines from carbon (C V and C VI) are in fact lines from ordinarily excited N V and O VI, respectively. Table 1 summarizes the new line identifications.

3. Two distinct post-AGB evolutionary sequences for H-deficient stars?

The O(He) stars are a small group of four objects (two have an associated PN) with parameters close to T_{eff} = 120000K and log g = 6 (Rauch et al. 1998, 2008, and Reindl et al. in these proceedings; Fig. 1). They have helium-dominated atmospheres and cannot be explained by a late flash like the PG1159 and [WC] stars, because evolutionary models always predict high C abundances. One can therefore argue that they are representatives of a distinct post-AGB sequence. If so, which stars are possible progenitors and successors?

It could be that some of the O(He) stars are evolved R CrB stars (T_{eff} around 7000 K) and we are currently investigating how metal abundance patterns compare (see Reindl et al. in these proceedings). Even if the relationship is identified, the question a16

bout their origin remains unanswered. R CrB stars may be the outcome of a double-degenerate merger, i.e. the coalescence of a carbon-oxygen WD with a helium WD. Merger simulations indicate that the resulting chemical abundance patterns are in qualitative agreement with observed abundances in R CrB stars, although it is not clear to what extent the resulting metal abundances are determined by the intershell composition of the C-O WD progenitor or by nucleosynthesis during merging (Jeffery et al. 2011, Longland et al. 2011). Helium-rich objects that bridge the large T_{eff} gap between the R CrB and O(He) stars could be the extreme He-B stars (EHeB, T_{eff} around 20 000 K) and a handful known low-gravity sdO stars (T_{eff} around 70 000 K, see e.g. Jeffery 2008).

Two of the O(He) stars have a significant amount of hydrogen (H/He = 0.1 and

0.5 by number in HS 1522+6615 and LoTr4, respectively; Rauch etal. 1998; Reindl etal. in these proceedings). Also, a few R CrB stars have much hydrogen (e.g. H/He = 0.5 in V854 Cen; Rao & Lambert 1996), as well as some EHeB stars. This is in conflict with the merger scenario because one would expect very little or no remaining hydrogen. It is speculated that an alternative origin are post-early AGB stars, i.e. rather low-mass objects that experience their first thermal pulse after departure from the AGB (Miller Bertolami & Althaus 2006).

Immediate progenitors of the O(He) stars might be [WN] central stars. Their existence, however, is still debated (Todt et al. 2010a). It is claimed that the central star of PB 8 ($T_{eff} \approx$ 50 000 K) is indeed a [WN] (or more precise: a [WN6]/[WC7] type), being He-dominated with a large H abundance (H/He/C/N/O = 40/55/1.3/2/1.3, mass fractions), and a possible relation to the O(He) class was discussed (Todt et al. 2010b). Miller Bertolami et al. (2011) argue that PB 8 might be the result of a diffusion-induced nova, which is an entirely different scenario to explain H-deficient post-AGB stars. It could perhaps also apply to the O(He) stars.

A potential successor of the O(He) stars could be the He-dominated KPD 0005+5106 (T_{eff} = 200000K, log g = 6.7; Wassermann et al. 2010). Its metal abundance pattern reveals strong commonalities with R CrB stars. Like the PG1159 stars, with increasing gravity the O(He) stars will evolve into DA or non-DA WDs depending on whether they retained hydrogen or not.

4. Evidence for H-deficient post-super AGB evolution

H 1504+65 is the hottest known white dwarf (T_{eff} = 200 000 K). Its high surface gravity (log g = 8) indicates a relatively high mass. Spectroscopically, it is related to the PG1159 class but it is a distinct object because it is not only hydrogen-deficient but also helium-deficient. The atmosphere is primarily composed of carbon and oxygen, by equal amounts Werner (1991). In addition, a high abundance of neon was derived Werner & Wolff (1999). The origin of this exotic surface chemistry (C = 49%, O = 49%, Ne = 2%, mass fractions) is completely unclear. We have speculated that H 1504+65 represents the naked C-O core of a white dwarf. Another, even more exciting possibility is that we see the eroded C-O envelope of a O-Ne-Mg white dwarf. This is corroborated by a Chandra soft X-ray spectrum (Werner et al. 2004) that allowed the detection of magnesium, with an abundance of about 2% (Fig. 5). Another strong argument in favor of this idea would be the detection of sodium, which would be direct evidence for C-burning. Stellar models predict that the ^{23}Na abundance at the bottom of the C/O envelope is comparable to that of neon (main isotope ^{20}Ne) and magnesium (^{24,25,26}Mg, Iben et al. 1997). We are analyzing new UV spectra taken with HST/COS aiming at the abundance determinations for Mg and Na (Werner et al. 2010).

It could turn out that H 1504+65 is one of the "heavy-weight" intermediate-mass stars ($8M_o \le M \le 10\ M_o$) that form white dwarfs with electron-degenerate O-Ne-Mg cores. At present it is uncertain under which circumstances super-AGB stars (i.e. the massive counterparts of AGB stars that ignite carbon but do not proceed to further stages of nuclear burning) produce O-Ne-Mg WDs or explode as electron-capture SNe producing NSs (e.g. Siess 2007). This uncertainty mainly arises from modeling uncertainties in mass-loss and mixing processes. The possibility that H 1504+65 is a O-Ne-Mg WD is remarkable, because evidence for the existence of such objects is rather scarce (Weidemann 2003). Evidence from single massive WDs is weak, and the most convincing cases are WDs in binary systems. Strong Ne overabundances are found in novae (Livio & Truran 1994) or in eroded WD cores in LMXBs (Juett et al. 2001). If a high Na abundance is found in H 1504+65, then this would be the most compelling case for the existence of a single O-Ne-Mg WD, i.e. a post super-AGB star. H 1504+65 would then also challenge stellar evolution theory relevant for super-AGB stars, because it cannot explain how the star has lost its H-rich and He-rich envelopes and why it exposes its metallic core.

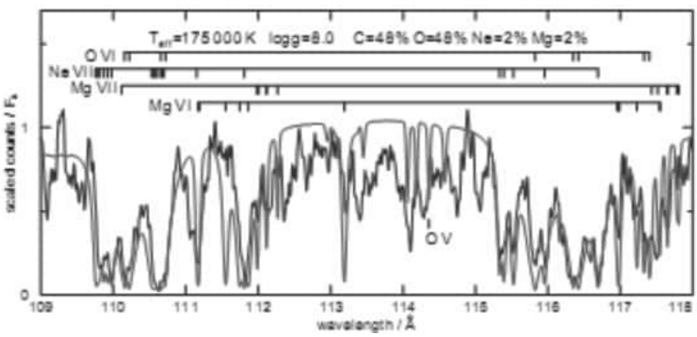

Figure 5. Detail from a Chandra soft X-ray spectrum of H 1504+65 and an overplotted model with parameters as noted in the panel.

At any rate, one may wonder where potential progenitors and successors with H1504-like chemistry are. All [WR] and PG1159 stars analyzed so far are still having significant amounts of helium in their atmospheres (30-50%) and always C >> O. Recently, a group of relatively cool white dwarfs ($T_{eff} \approx$ 20 000 K) with almost pure carbon atmospheres were discovered (so-called "hot DQs"; Dufour et al. 2007, 2010). They may be evolved H1504-like stars because one can expect that at some point in future evolution carbon as lightest element will float on top of H 1504+65.

Recently, Gansicke et al. (2010) discovered a new class of two O-rich white dwarfs (He-dominated atmospheres with O/He ≈ 0.01 and O > C, by number, and T_{eff} around 10 000 K) that could be O-Ne-Mg white dwarfs.

5. Summary and conclusion

The rich diversity of hydrogen-deficient central stars of planetary nebulae and related objects is not well understood. The majority consists of [WC] and PG1159 stars which are thought to form an evolutionary sequence that is caused by a late helium-shell flash in post-AGB stars. The helium-dominated O(He) stars suggest that there exists at least one additional H-deficient sequence that is caused by a double-degenerate merger. It is possible that the O(He) stars are the progeny of R CrB stars.

There is growing evidence that there exists a H-deficient post-super AGB white-dwarf cooling sequence consisting of remnants with O-Ne-Mg cores. H 1504+65 with its CO dominated atmosphere might mark the hot end of this sequence while the recently discovered groups of C-dominated “hot DQs” and He-dominated O-rich white dwarfs occupy cooler regions. The origin of H-deficiency in post-super AGB stars is unknown. There is no obvious hint as to which central stars of planetary nebulae could be related to these chemically peculiar white dwarfs.

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SAMPLE **RESEARCH PAPER 2**

DIERINGER, G., CABRERA, L. R., AND M. MOTTALEB. 2014. Ecological relationship between floral thermogenesis and pollination in nelumbo lutea (nelumbonaceae). *American Journal of Botany 101(2):* 1-8.

Ecological relationship between floral thermogenesis and pollination in *nelumbo lutea* (nelumbonaceae)[1]

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- *Premise of study:* Floral thermogenesis is an unusual floral trait with a well-documented physiological process, and yet, there is limited understanding of how this trait influences plant reproduction. The current study was undertaken to gain a better understanding of how floral thermogenesis in *Nelumbo lutea* impacts pollinator attraction and consequent plant reproduction.
- *Methods:* We conducted field studies on floral thermogenesis and thermoregulation, flower sexual development, floral visitation patterns, breeding system, pollen transfer dynamics, and floral scent production.
- *Key results:* The most abundant visitors to the thermoregulatory flowers included the Phoridae (Diptera), Chrysomelidae (Co-leoptera), and Hymenoptera. Chrysomelid beetles, particularly *Diabrotica*, were frequent visitors to both first-day female- and second-day bisexual-phase flowers, while phorid flies were most common in bisexual-phase flowers. Pollen transfer experiments indicated that *Diabrotica* was equally effective in depositing pollen on stigmas, as were the less frequent, but *pollen-loaded halictid bees.*
- *Conclusions:* Flowers received a taxonomically wide assemblage of floral visitors and appear adapted to attract beetles, primarily Chrysomelidae and medium-sized bees. This study is the first to provide strong support that beetles can comprise the dominant portion of floral visitors and are as effective in pollen transfer as

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bees. Thermogenesis aids in dispersing the main floral scent component—1,4-dimethoxybenzene—attracting both chrysomelids and bees, while thermoregulation causes chrysomelid beetles to actively seek out new flowers for evening residence. This search behavior likely results in chrysomelids affecting cross-pollination.

Keywords: beetle pollination; Chrysomelidae; Halictidae; *Nelumbo lutea*; Nelumbonaceae; Phoridae; thermogenesis; thermoregulation.

Thermogenesis, as a floral trait, was first described by Lamarck (1778; cited in Raskin, 1992) for *Arum* (Araceae) and then for the genus *Nelumbo* (Nelumbonaceae) by Miyake (1898). Despite this long history of knowledge, there continues to be a strong interest in floral thermogenesis with a long list of studies documenting additional thermogenic taxa, physiology, and molecular bases of thermogenesis. Our objective here is to investigate the ecological relationship between floral thermogenesis, pollinator attraction, and consequent plant reproduction using *Nelumbo lutea.*

Since 1778, 12 families of plants have been reported to exhibit floral themogenesis including the Cycadaceae, Cyclan-thaceae, Araceae, Annonaceae, Arecaceae, Aristolochiaceae, Nymphaeaceae (cf. Endress, 1994; Knutson, 1974; Seymour and Schultze-Motel, 1996), Magnoliaceae (Dieringer et al., 1999) Illiciaceae (now included within Schisandraceae (Stevens, 2001 onwards) (Dieringer et al., 1999); Rafflesiaceae, Schisandraceae (cf. Thien et al., 2009), and Hydnoraceae (Seymour et al., 2009). In addition to floral thermogenesis, members of two families have also displayed the ability to thermoregu-late their flowers (e.g., *Philodendron* (Araceae) and *Nelumbo* (Nelumbonaceae) (Gibernau et al., 1999; Seymour and Schultze-Motel, 1996; respectively).

Floral thermogenesis and its association with basal angiosperms was first pointed out by Dieringer et al. (1999), and elaborated upon by Azuma et al. (1999), Thien et al. (2009), and Endress (2010). Within basal angiosperms, floral thermogenesis is exhibited by large-flowered, protogynous, beetled-pollinated taxa (Thien et al., 2009), which are also characteristics of the more derived family Nelumbonaceae.

Thermogenic flowers produce heat via an alternative, cyanide-resistant respiratory pathway (James and Beevers, 1950; cited in Raskin, 1992). Thermogenic flowers are typically pollinated by flies and beetles with above-ambient temperatures ranging from 0.2°C in male-phase flowers of *Magnolia tamau-lipana* A. Vazquez (Dieringer et al., 1999) to as much as 25.6°C in spadices of *Symplocarpus foetidus* (L.) Salisb. ex Nutt. (Seymour, 2010). Physiological studies have shown that thermoregulating flowers precisely regulate heat production; for example, flowers of *Nelumbo nucifera* Gartn. maintained floral temperatures between 30-35°C during anthesis (Seymour and Schultze-Motel, 1996). Heat production typically coincides with stigma receptivity and scent production although usually this begins before anthesis and continues for several days after in *N. nucifera* (Seymour and Blaylock, 2000).

The value of floral heat production comes from volatilization of floral scent to attract potential pollinators, protection of flowers during short periods of cold, enhancement of pollen germination and growth, and optimum development of insect larva (Ervik and Barfod, 1999; cited in Thien et al., 2009). Endothermic *Cyclocephala caelestis* Delgado and Radcliffe (Scarabaeoidea) beetles lower thoracic temperatures while visiting night-flowering thermogenic flowers of *Magnolia* (Dieringer et al., 1998). Studies on *Cyclocephala colasi Endrodi* visiting night-flowering thermogenic inflorescences of *Philodendron* have been shown to expend 2.0-4.8 times more energy when active outside the flower than inside (Seymour et al., 2003); the floral heat thus reducing the energetic cost of maintaining the beetles' thoracic temperature. Within flowers, the conserved energy allows visiting insects to forage and mate.

Flowers of *Nelumbo* are typically categorized as beetle-pollinated based on their large flower size, numerous tepals and stamens, staminal appendages, protogynous flower development, strong floral scent, and diurnal tepal movements that form a chamber at night (Bernhardt, 2000). Despite the frequent reference to *Nelumbo* as beetle-pollinated (Sohmer and Sefton, 1978; Schneider and Buchanan, 1980; Li and Huang, 2009), most studies have failed to demonstrate beetles as specialized or principal pollinators or even frequent floral visitors. Field studies on *N. lutea* (Willd.) Pers., *N. pentapetala* (Walter) *Fernal*d (syn. *N. lutea*), and *N. nucifera* have found a taxonomi-cally wide assemblage of floral visitors capable of moving pollen between flowers including Hymenoptera, Coleoptera, Diptera, and Lepidoptera (Robertson, 1889; Sohmer and Sefton, 1978; Schneider and Buchanan, 1980) leading Bernhardt (2000) to consider *Nelumbo* as possessing a generalist flower and Vogel and Hadacek (2004) to consider the insects' behavior as opportunistic.

While Schneider and Buchanan (1980) have documented flowers of *Nelumbo lutea* as thermogenic, floral thermoregulation has not yet been recorded for this species. The present field study was undertaken to estimate ecological relationships between floral themogenesis, thermoregulation, and plant-pollinator interactions using *N. lutea*. The study included examining patterns of insect visitation to flowers across time-of-day and sexual development, determination of the breeding system, and field experiments on pollen transfer dynamics of principal floral visitors. Documentation of floral scent production and thermogenesis was undertaken to determine the extent to which flowers are adapted to attracting beetles, and the overall contribution that beetles may have toward pollination and reproduction in *N. lutea*.

MATERIALS AND METHODS

The field study was conducted at Squaw Creek National Wildlife Refuge (NWR), Mound City, Missouri, USA during the summers of 2003-2005, 2007, 2011, and 2012 in areas known as Bluff Pool and Cattail Pool. The refuge is located in Northwestern Missouri within the historic Missouri River floodplain, and protects 7350 acres of wetland and loess hill prairie. The wetlands are managed to provide suitable habitats for migrating waterfowl and shorebirds.

Nelumbo lutea is an emergent aquatic clonal plant with rhizomes buried in the lake bottom. Plants send up flowering peduncles from the rhizome, and each peduncle bears one flower with flowers bent toward the rising sun. Flowers possess an enlarged obconical receptacle with multiple free pistils, each containing a single ovule. Ovaries mature into nutlets. Pistils, embedded in the receptacle tissue, vary in number from 6-34 (mean = 24.9 pistils per flower ±SE = 0.98, N = 38 peduncles, this study). When sampling plants and reporting sample size, only the number of peduncles or number of flowers is noted because the number of genetically distinct plants sampled was unknown. Voucher specimens were deposited at the University of Missouri (*Dieringer and Cabrera R. 29, Dieringer and Cabrera R. 30*; UMO).

The study of floral biology included, ultraviolet (UV) photography of flowers, floral sexual development, rates of insect visitation, and breeding system. Ultraviolet light photography was performed using a Kodak Wratten 18A UV filter attached to a Pentax 35 mm camera and taken in sunlight using 400 ASA Fuji black and white film with 6-8 s exposures.

Notation of floral sexual development was documented by tagging peduncles of flower buds and returning daily to note sexual phases (N = 10 flowers). Anthesis began in early morning around 0630-0700 h depending on ambient temperature with tepals beginning to unfold. Upon opening, flowers were pro-togynous with stigmas that were yellow, turgid, and possessing a mucilage (receptive). Tepals were tightly appressed to the undehisced stamens and receptacle side; staminal appendages were also tightly folded over and onto the receptacle surface. Flowers began closing around 1400 h and ultimately formed a chamber by 1800 h that could house floral visitors throughout the night. On the second day, flowers began a male-phase with anthers dehisced, but the stigmas were still yellow and turgid (receptive) and, hence, considered functionally bisexual. it should be noted, however, that Seymour and Blaylock (2000) showed a marked decrease in peroxidase activity (receptivity) on this day for N. nucifera. Flowers again began closing around 1400 h. On the third day, flowers again opened in early morning with the stigmas dry and brown (unreceptive), and anthers and tepals beginning to abscise.

Rates of floral visitor abundance were recorded as changes in number of visitors within flowers over time-of-day and sexual phase. An insect was considered a floral visitor no matter where it was observed on the flower; that is, on tepals, within tepals at the base of the flower, on the enlarged receptacle, or in direct contact with anthers or stigmas. In August 2003, arthropod abundances were recorded for a random set of flowers without regard to sexual phase for three time periods per day; 0630 h, 1100 h, and 1600 h over five days (N = 21 flowers). To observe differences in insect visitation between sexual phases, insect abundance was recorded separately for first-day female- and second-day bisexual-phase flowers across three time-periods; 0800 h, 1200 h, and 1500h for four days in August 2004 and five days in July 2005 (N = 20 flowers each year).

The breeding system was determined by an experimental series of hand-pollinations using flowers previously enclosed in mesh cloth bags to exclude floral visitors. Types of crosses included: (1) autogamy, no hand-pollination to test for automatic self-pollination; (2) self-pollination, intrafloral pollen transfer to test whether self-pollen would fertilize ovules, performed on bisexual-phase flowers; and (3) xenogamy, pollen being transferred from flowers at least 1 m away. Sample sizes ranged from 10-38 flowers per cross. Resultant fruit production from breeding system experiments was compared among crosses and that from open-pollinated flowers using likelihood ratio tests.

To estimate the effect of insect visitation on first-day female-phase flowers, 20 flowers were bagged after being exposed to open-pollination on the first day of anthesis. The number of available ovules and resultant production of fruits was recorded and compared with that from flowers open to natural pollination across their 2-d lifespan using a *t* test.

After a review of data in 2011, we decided to collect additional data on pollen loads and pollen transfer dynamics of our two most common floral visitors—*Diabrotica* (Chrysomelidae) and phorid flies—and to compare those data with halictid bees, which were noted as common visitors and important pollinators in other studies (Robertson, 1889; Sohmer and Sefton, 1978; Schneider and Buchanan, 1980). In 2012, flower visiting *Diabrotica*, phorid flies, and halictid bees, principally *Augochlorella*, were captured and euthanized in kill jars containing ethyl acetate. Each group was kept in separate jars to avoid cross-contamination. Individual insects were then stored at -20°C in separate microfuge tubes for later analysis. For *Diabrotica* and phorid flies, specimens were examined microscopically for presence and location of pollen, placed on a slide, and washed with absolute ethanol while gently dislodging the pollen from the body with a dissecting needle; the ethanol was allowed to evaporate. Dried slides were mounted in a glycerin jelly basic fuschin mixture and the pollen grains were counted microscopically. For halictid bees, 0.5 mL of alcohol-containing detergent was added to the microfuge tube and allowed to set for a few minutes, and was then shaken to remove pollen adhering to the body and scopae. The number of grains in four aliquots was counted using a hemocytometer, and the total number of grains was estimated by accounting for dilution. Pollen loads were compared among floral visitors using a Kruskal-Wallis test.

Pollen transfer dynamics were estimated by bagging flower buds with a cloth mesh bag and then removing the bag the next morning at anthesis, flowers being female-phase. Flowers were observed until visited by *Diabrotica*, a phorid fly, or a halictid bee. Once the insects were observed to walk across a stigma, that stigma was marked with a permanent marker and the flower re-bagged. Marked stigmas were removed the following morning and fixed in a formalin-glacial acetic acid-alcohol mixture. Fixed stigmas were cut in half, cleared using Visikol (Phytosys LLC, New Brunswick, New Jersey, USA) overnight, then mounted and squashed on slides in a glycerin jelly basic fuschin mixture. Pollen grains adhering to the stigmatic surface were counted microscopically. Pollen deposition was compared between visiting insects and that of female-phase, open-pollinated stigmas using a Kruskal-Wallis test. All statistical analyses followed the guidelines of Sokal and Rohlf (1995), and the data were analyzed using JMP® v5.0.1 software (SAS Institute, 2002).

Floral and ambient temperatures for 20 randomly chosen flowers were recorded for three time-periods per day over a three-day period; the two days of anthesis and the day following anthesis. In addition, floral and ambient temperatures for a single flower were recorded every half-hour over a five-day period starting the day before anthesis and continuing two days past anthesis. Floral and ambient temperatures were recorded using copper-constantan thermocouples (0.3 mm in diameter) connected to a portable battery powered digital thermometer (Omega Engineering, Stanford, Connecticut, USA) accurate to ± 0.01°C. Thermometers were attached to a metal pole and pushed into the sediment of the pool. Flower temperatures were taken by placing the thermocouple wires into the receptacle. Ambient temperatures were taken with thermocouples placed approximately 30 cm to the side of the flower. In the field, ambient and flower temperatures as measured by thermocouple wires were exposed to solar radiation and hence, subject to solar heating.

To collect floral scent volatiles, five bisexual-phase flowers were enclosed in a polyethylene bag in the field. The air, filled with volatiles, was pumped through a glass cartridge (6 mm ID X 5 cm) containing absorbent (50 mg Tenax TA, Mesh 60/80, GL Scientific Instrument Services, Ringoes, New Jersey, USA) via a battery powered mini-pump (Model MP-X30, Shibata Scientific Instruments, Tokyo, Japan) for approximately 24 h. The glass cartridges containing trapped floral scent were wrapped in aluminum foil and stored at -20°C for later analysis. Blanks were simultaneously collected from an empty polyethylene bag. Prior to sampling, the absorbent was washed successively with two volumes of distilled methanol and diethyl ether and heated for several hours at 150°C to remove any residual scent.

Volatile and semivolatile compounds were eluted from the absorbent with 0.5 mL distilled diethyl ether. Gas chromatography-mass spectrometry (GC-MS) was completed with a Varian 450 gas chromatograph (GC) interfaced with a 320 TQ mass spectrometer (MS) (Agilent Technologies, Santa Clara, California, USA) working in the electron-impact ionization mode at 730 eV. Samples were dissolved in diethyl ether and injected split-less into a BP50 capillary column (30 mm X 0.25 mm; 25|lm film thickness; SGC Analytical Science, Austin, Texas, USA). Injection port and detector temperatures were 230°C and 220°C, respectively. The column temperature was initially held at 50°C for 5 min and then increased by 10°C/min to 250°C with isothermal hold at this temperature for 10 min. Helium carrier gas was used with a flow rate of 1.0 mL/ min. Data acquisition and analysis were controlled by the Varian MS workstation computer software. Unknown compounds were identified by computer search of the Varian reference library incorporating mass spectra of reference compounds. Concentrations of compounds were calculated by integration of peak areas.

RESULTS

The protogynous, UV absorptive flowers displayed a typical two-day cycle of reproduction. In 2003, flowers, without regard to sexual phase, were visited by a taxonomically wide assemblage of arthropods of which 78% were insects (Table 1); Of the 699 insects observed, Diptera was the most abundant order comprising 83% of all insect visitors, 98% of which were members of the Phoridae. The second most abundant order was the Coleoptera comprising 10% of all insect visitors, of which 69% were the Chrysomelidae. Of the Chrysomelidae, 27 of the 47 (57%) observed were *Diabrotica undecimpunctata* Manner-heim. Total numbers for other visiting groups were so small that generalizations on visitation were not possible.

Table 1. Number of arthropod visitors to flowers (both sexual phases) of *Nelumbo lutea* across three time periods at Squaw Creek National Wildlife Refuge for five days in August 2003 (N = 21 flowers). Parentheses indicate totals for the taxonomic group.

Time of day				
Taxon	0630	1100	1600	Total
Class Arachnida (191)				
Order Araneae (10)				
F. Thomisidae	3	3	4	10
Subclass Acari (181)	86	68	27	181
Class Insecta (699)				
Order Odonata (1)				
Suborder Zygoptera		1		1
Order Orthoptera (1)				
F. Tettigoniidae			1	1
Order Hemiptera (3)				
F. Reduviidae			3	3
Order Coleoptera (68)				
F. Cantharidae			2	2
F. Curculionidae	1	1	3	5
F. Coccinellidae	1	2	9	12
F. Chrysomelidae	20	14	13	47
F. Cerambycidae		1	1	2
Order Hymenoptera (31)				
F. Halictidae		5		5
F. Megachilidae		6		6
F. Apidae	5	10	5	20
Order Lepidoptera (13)				
F. Crambidae	3	3	7	13
Order Diptera (582)				
F. Phoridae	164	160	247	571
F. Syrphidae		4	3	7
F. Tabanidae		1		1
Unknown		3		3
Total	283	282	325	890

When comparing sexual phases of the flower, insect abundance was 7x more abundant to bisexual-phase flowers (526 visits) than to female-phase flowers (73 visits; Table 2). As in 2003, the same pattern of visitation was observed with flies and beetles being the most abundant visitors (53% and 34%, respectively). Of all visitors, the Phoridae and Chrysomelidae were again the most abundant families comprising 90% and 56% of their respective orders. Female-phase flowers received a lower proportion of the total insect visitors (12%), but of those visitors, the most abundant were chrysomelids (38%). For bisexual-phase flowers, again the Phoridae and Chrysomelidae were the most abundant visitors; 50% and 17%, respectively. Bees accounted for 12.5% of the total visits with 27% being Halictidae (primarily *Augochlorella*). Bees typically (93%) visited second-day bisexual flowers to collect the abundant pollen.

Table 2. Number of insect visitors to flowers of *Nelumbo lutea* at Squaw Creek National Wildlife Refuge. Data were pooled across three time periods per day; 0800 h, 1200 h, and 1500 h; and across four days in August 2004 and five days in July 2005 (N = 20 flowers each year). Parentheses contain totals for the taxonomic group.

	Flower sexual phase		
Order/Family	Female	Bisexual	Total
Order Coleoptera (204)			
Cantharidae	3	20	23
Curculionidae	11	31	42
Coccinellidae	3	21	24
Chrysomelidae	28	87	115
Order Hymenoptera (75)			
Halictidae	2	20	22
Apidae	3	50	53
Order Diptera (320)			
Phoridae	22	265	287
Syrphidae		4	4
Unknown	1	28	29
Total	73	526	599

Breeding system experiments showed significant differences among crossing treatments (Table 3). The self-compatible flowers exhibited a high capacity for outcrossing and a limited amount of autogamy (18%) with 90% of open-pollinated pistils producing fruits.

Table 3. Breeding system of *Nelumbo lutea* at Squaw Creek National Wildlife Refuge in August 2003. Significant differences occurred across breeding system treatments (Likelihood Ratio X^2 = 750.03, df= 3, $P < 0.0001$ across all treatments; all pairwise comparisons except for open vs. self were also significant, $P < 0.0001$).

Treatment	$N_{flowers}$	$N_{pistils}$	N_{fruits}	% fruit production
Autogamous	21	422	77	18.3
Selfed	10	262	226	86.3
Xenogamous	17	447	275	61.5
Open-pollinated	38	947	850	89.8

Of the 20 flowers bagged to test the effect of insect visitation to first-day female-phase flowers, 3 were lost to inclement weather. Resultant fruit production from these crosses was compared with that from open-pollinated flowers (Table 4). The 17 female-phase flowers possessed a total of 444 pistils, of which 309 (70%) produced fruits, while open-pollination flowers had 90% of pistils produce fruits (Table 3). No significant difference was detected in mean fruit production per flower between first-day female-phase flowers and those open to pollination across the life of the flower.

Table 4. Mean fruit production from open-pollinated flowers of first-day female-phase flowers compared with flowers visited over both days of anthesis at Squaw Creek NWR in July 2007. Data for mean fruit production of flowers left open to insect visitation over both days of anthesis consisted of the same set of flowers used in Table 3 for open-pollinated flowers. Means were compared using a *t* test for unequal variances.

Treatment	N	Mean	SE	Range	t	df	P
First-day	17	18.2	1.57	2-30	1.89	22.37	0.07
female-phase							
Available both	38	22.4	1.05	5-28			
days of anthesis							

Pollen loads of Diabrotica, phorid flies, and halictid bees differed significantly from each other (Table 5); Pollen loads on Diabrotica averaged in the hundreds vs. thousands found on halictid bees. Phorid flies however carried extremely few pollen grains with 15 of the 20 specimens (75%) carrying no pollen at all.

Table 5. Mean pollen load of the three most common floral visitors to *Nelumbo lutea* flowers at Squaw Creek NWR in July 2012 compared to pollen deposition on stigmas of open-pollinated flowers. Significant differences determined by a Kruskal-Wallis test; multiple comparisons made using Wilcoxon two-sample tests with a = 0.017 using the Bonferroni Method. All means were significantly different from each other.

	N	Mean	SE	X^2	df	P
Diabrotica	27	247.0	50.1			
Halictid bee	25	25144.4	2797.0	63.30	2	<0.0001
Phorid fly	20	2.2	1.7			

Interestingly, pollen transfer experiments indicated that *Dia-brotica* and halictid bees did not differ in the mean number of grains deposited on stigmas following a single visit despite the large difference in pollen carried on their bodies (Table 6), but their deposition did differ from stigmas open to visitation throughout the first day of anthesis. Unfortunately, extremely few phorid flies came into direct contact with stigmas and hence could not be compared statistically with other visitors, having spent most of their time simply alighting on tepals or moving into tepal folds at the flower base.

Table 6. Mean pollen deposited by a single-visit to a stigma for the three most common floral visitors to *Nelumbo lutea* compared to pollen deposited on stigmas of open-pollinated, female-phase flowers at Squaw Creek NWR in July 2012. Significant differences determined by a Kruskal-Wallis test; multiple comparisons made using Wilcoxon two-sample tests with a = 0.017 using the Bonferroni Method. Phorid flies were not included in the analysis given the small sample size.

Floral visitor	$N_{stigmas}$	Mean	SE	X^2	df	P
Diabrotica	25	4.9[a]	2.33			
Halictid bee	24	2.1[a]	0.62	19.46	2	<0.0001
Prohid fly	2	0	0.0			
Open-pollinated flowers	21	12.62[b]	2.51			

Different letters indicate significant differences at P<0.05.

During the two days of anthesis, mean floral temperatures varied little ranging from 33.87-35.99˚C (Table 7). In contrast, mean ambient temperatures at this time varied greatly ranging from 18.44-31.06˚C (Table 7). This is also evident in Fig. 1 where flower temperatures, plotted for an individual flower over five days, ranged from 30.2-38.9˚C during anthesis, while ambient temperatures ranged from 10.2-33.0˚C over the five days. On the third day of flower opening, flowers were considered inviable with flower temperatures dropping to a mean of 26.53˚C early in the morning (Table 7) then progressively approaching and tracking ambient temperature over the next two days (Fig. 1).

Table 7. Mean flower and ambient temperatures (˚C) for three stages of flower development for *Nelumbo lutea* at Squaw Creek NWR on 25 July 2003. Standard errors are presented in parentheses. N = number of flowers sampled.

		Time (h)					
		0630		1200		1500	
Sexual phase	N	flower	ambient	flower	ambient	flower	ambient
First day (female)	20	35.99 (0.22)	19.10 (0.08)	34.72 (0.25)	30.64 (0.33)	34.91 (0.18)	30.22 (0.24)
Second day (bisexual)	20	35.36 (0.28)	18.44 (0.03)	34.75 (0.21)	30.28 (0.28)	33.87 (0.20)	31.01 (0.19)
Third day (inviable)	20	26.53 (0.67)	19.04 (0.11)	34.42 (0.27)	30.23 (0.29)	34.03 (0.27)	31.16 (0.34)

A total of 27 compounds were identified in the floral scent of *Nelumbo lutea* using GS-MS (Table 8); Aliphatics, aromatics, and terpenes were detected in the samples, with a concentration range from 0.05-81.3%. The three most predominant components of floral scent were 1,4-dimethoxybenzene (81%), pentadecane (4%), and a -farnesene (3%).

Table 8. List of identified floral volatiles of *Nelumbo lutea* flowers collected at Squaw Creek NWR in 2011, as analyzed by gas chromatography-mass spectrometry. Scent was obtained from a collection of five bisexual-phase flowers.

Compound	Molecular formula	Peak area %
Aliphatic compounds		
Undecane	$C_{11}H_{24}$	0.0893
Tridecane	$C_{13}H_{28}$	0.2423
Pentadecane	$C_{15}H_{32}$	3.7310
Eicosane	$C_{20}H_{42}$	0.2697
Squalene	$C_{30}H_{50}$	1.2389
3,7-dimethyl-1-(2,5-xylyl)-octane	$C_{8}H_{30}$	0.2062
2-ethyl-1-hexanol	$C_{8}H_{18}O$	0.7354
4-bromo-1H-pyrozole	$C_{3}H_{3}BrN_{2}$	0.1657
2,6,10-trimethyl tetradecane	$C_{17}H_{36}$	0.0493
1-pentadecene	$C_{15}H_{30}$	1.0514
2,6,10-trimethyl hexadecane	$C_{19}H_{40}$	0.1278
3,3,5-trimethyl-cyclohexanone	$C_{9}H_{16}O$	1.4942
Phthalic acid, butyl tridec-2-yn-1-yl ester	$C_{25}H_{36}O_{4}$	0.3634
Aromatic compounds		
1,4-dimethoxybenzene	$C_{8}H_{10}O_{2}$	81.3430
1,2,4-trimethoxybenzene	$C_{9}H_{12}O_{3}$	0.1282
1-methoxy-4-methylbenzene	$C_{8}H_{10}O$	0.0834
p-anisic acid, 4-nitrophenyl ester	$C_{14}H_{11}NO_{5}$	1.0413
Carbamic acid, N-(1,1-bis(trifluoromethyl) ethyl)-, 4-(1,1,3,3-tetramethylbutyl) phenyl ester	$C_{19}H_{25}F_{6}NO$	1.0846
Benzyl benzoate	$C_{14}H_{12}O_{2}$	0.5120
1,1,3,3-tetramethylbutyl)-phenol	$C_{14}H_{22}O$	0.2253
Octahydro-4b,8-dimethy-2-isopropylphenanthrene	$C_{19}H_{28}$	0.4110
Butylated hydroxy toluene	$C_{15}H_{24}O$	0.1374
4-(1,1,3,3-tetramethylbutyl)-phenol	$C_{14}H_{22}O$	0.2253
Terpenes/Terpenoids		
Caryophyllene	$C_{15}H_{24}$	0.5423
α -farnesene	$C_{15}H_{24}$	3.3028
(2-indanyl)(4-morpholyl)-methanone	$C_{14}H_{317}NO_{2}$	1.0361

DISCUSSION

Floral thermogenesis has been described primarily in basal angiosperms and is known to be associated with attracting fly and beetle pollinators, however, the ecological relationships between floral thermogenesis and plant-pollinator interactions are still poorly understood. The genus *Nelumbo* also possess thermogenic properties and floral traits typical of basal angiosperms that are beetle pollinated. Nevertheless, most studies have documented various groups of floral-visiting insects as potential pollinators. Here we relate floral thermogenesis to plant reproduction and pollination of N. lutea by halictid bees and chrysomelid beetles.

The flower development and reproductive cycle of *Nelumbo lutea* were similar to those described in other studies of the genus (Schneider and Buchanan, 1980; Seymour and Schultze-Motel, 1996, 1997). Flowers were UV absorptive, protogynous, and exhibited thermogenesis at least one day prior and one day after anthesis. During the two-day cycle of reproduction, flowers exhibited thermoregulation with only modest variation in flower temperatures that were independent of ambient temperatures (Fig. 1). Floral tepals exhibited diurnal movements with tepals folding up in the afternoon forming a chamber within which occasional insects (mainly *Diabrotica* in this study) could be found. Tepals continued this behavior even following the two-day cycle of reproduction as long as tepals remained attached to the receptacle. This study is the first to document thermoregulation for *N. lutea*.

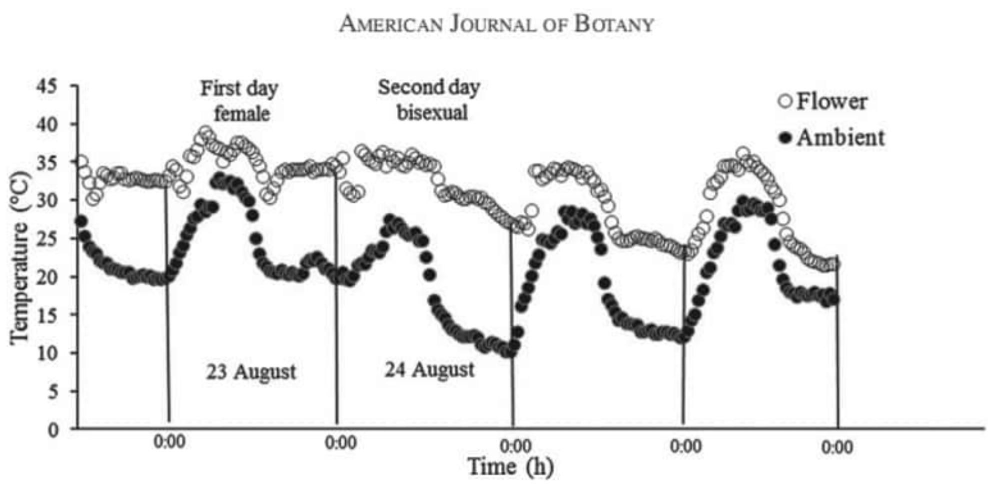

Fig. 1. Ambient and flower temperatures (˚C) for Nelumbo lutea over a five-day period in August 2003 at Squaw Creek National Wildlife Refuge showing bud stage (22 August) through flower anthesis (23 and 24 August) and flower senescence (25 and 26 August). Time of 0:00 h represents midnight.

Flowers were self-compatible, as noted in studies of *N. nu-cifera* (Kasumi and Sakuma, 1998; Li and Huang, 2009) and exhibited a strong capacity for outcrossing. Flowers also demonstrated a slight potential for autogamy.

The assemblage of floral visitors recorded was taxonomi-cally broad and similar to that of other studies on the genus (summarized by Vogel and Hadacek, 2004). Not surprisingly, the list of arthropod visitors included mites, crab spiders, and *Ostrinia* larvae (a crambid moth seed predator); all previously noted as floral visitors (Center et al., 2002; Tian, 2008). In the current study Diptera and the Coleoptera, especially the Chry-somelidae (as in Sohmer and Sefton, 1978), were the most frequent floral visitors. Flies and beetles are typical visitors to thermogenic flowers (Dieringer et al., 1999). Visiting insects have been observed to feed or gnaw on the stigmatic mucliage (Sohmer and Sefton, 1978; Li and Huang, 2009; this study) and while the staminal appendages have at times been referred to as food bodies (Sohmer and Sefton, 1978), no field studies have confirmed this but rather indicate they are osmophores (Vogel and Hadacek, 2004).

Analysis of floral scent indicated that Nelumbo lutea flowers produced an abundance of 1,4-dimethoxybenzene (1,4-DMB) (81%), typical for other studies on *N. lutea* (97%) and *N. nu-cifera* (84%) (Omata et al., 1991; Vogel and Hadacek, 2004; respectively). For *N. nucifera*, the three most prominent compounds comprising the floral scent included 1,4-DMB, caryo-phyllene, and pentadecane (Omata et al., 1991), while we found the most prominent for N. lutea were 1,4-DMB, pentadecane, and a-farnesene.

The scent 1,4-DMB has also been found in the floral scents of 13 families of angiosperms (reviewed in Knudsen et al., 2006). Some of these include the Salicaceae, *Salix* visited by andrenid bees (Dotterl et al., 2005); the Orchidaceae, *Ana-camptis* pollinated by apid bees (Salzmann et al., 2007); neotropical palms pollinated by beetles from the Chrysomel-idae, Curculionidae, and Nitidulidae (Knudsen et al., 2001); and the Cucurbitaceae, *Cucurbita* pollinated by chrysomelid beetles (Andersen, 1987). Ventura et al. (2000) demonstrated 1,4-DMB to be very attractive to chrysomelid beetles includ-ing *Diabrotica*.

The most abundant insect visitors to *N. lutea* were phorid flies. Phorids are typically recorded in flowers with moist decaying matter and are noted for feeding on decaying organic matter, but were also recorded as important pollinators of the Araceae where spathes serve as sites for larval development (Sakai, 2002; Rulik et al., 2008). In studies on *Herrania* (Ster-culiaceae), phorids transported pollen on the notal and head areas (Young, 1984). In this study, phorids carried pollen primarily on the proximal areas of pro- and mesothoracic legs. Previous studies showed that phorids are capable of transporting pollen and affecting pollination in the Orchidaceae and Aristolochi-aceae (Borba and Semir, 2001; Rulik et al., 2008; respectively). For *N. lutea*, phorids would likely be ineffectual in transferring pollen from bisexual- to female-phase flowers (cross-pollination), because most (92%) were observed in bisexual-phase flowers (Table 2) and hence, not moving frequently to female-phase flowers (Tables 5 & 6). In the 20 h spent in the field observing hundreds of flowers for the pollen transfer experiments, phorid flies were only observed to contact two stigmas and neither transferred pollen.

Chrysomelids were the most abundant beetles with *Diabrot-ica undecimpunctata* being most common (see also Sohmer and Sefton, 1978). Arriving beetles typically alighted on the floral receptacle or tepals and would eventually move toward the flower. While visiting the flower, beetles would occasionally walk across stigmas, gnaw on stigmas, or gnaw on anthers. On rare occasions, beetles were observed mating in flowers while the beetles were located toward the flower base. Our field observations, like those of Sohmer and Sefton (1978) frequently noted *D. undecimpunctata* inside floral chambers during the afternoon. The current study differs from most others in documenting Coleoptera as a principal component of the visitor assemblage (Schneider and Buchanan, 1980; Li and Huang, 2009). Vogel and Hadacek (2004) indicated that these studies provide suggestive data that the Chrysomelidae and in particular, *Diabrotica*, is an important or at least appropriate insect pollinator for the genus *Nelumbo* because *Diabrotica* is listed in all previous studies.

Schneider and Buchanan (1980) observed numerous visits by the beetle *Chauliognathus* (Cantharidae), however, we observed very few on female-phase flowers in 2003 through 2005 and none in 2012. Studies on *Nelumbo* by Schneider and Buchanan (1980) and Li and Huang (2009) both observed bees as the most common visitor and indicated they were the most effective pollinators as well, based on the pollen loads they typically carry and frequent contact with stigmas. Our pollen transfer experiments clearly indicated that single flower visits by *Diabrotica* were equally effective in depositing pollen on stigmas, as were single flower visits by halictid bees even though pollen loads differed greatly. Halictid bees, although not common on female-phase flowers, did frequently contact stigmas when visiting, and at times were observed to gnaw on stigmas. Other bees, such as *Apis mellifera*, were typically seen collecting pollen from bisexual flowers and were noted as visiting female-phase flowers on occasion in 2003 through 2005, although no honeybees were observed on female-phase flowers in 2012.

Nelumbo lutea, like *N. nucifera* (Seymour and Schultze-Motel, 1996), was not only thermogenic, but also thermoregulatory. Studies by Seymour et al. (2003) on thermogenic *Philodendron* showed that heat from the flowers can serve as a reward for visiting *Cyclocephala* beetles. *Cyclocephala* beetles are endo-thermic and maintain an elevated thoracic temperature whether inside or outside of flowers (Dieringer et al., 1998). While foraging and mating inside thermogenic flowers, the beetles' thoracic temperature drops (Dieringer et al., 1998) such that the energetic cost of maintaining the thoracic temperature is reduced (Seymour et al., 2003).

However, not all beetles are endothermic nor restrict their foraging and mating activities to evening hours. *Diabrotica* is a clear example of a diurnal ectothermic beetle that relies on mi-crosite selection for regulation of body temperature and does so when ambient temperatures drop below 13 ˚C (Meinke and Gould, 1987). In the current study, daytime ambient temperatures typically ranged from the 20's˚C to

30's°C. Evening lows do occasionally fall to 13 °C or lower in late July or early August and dropped to 10.2°C during this study in 2003. As previously noted, *Diabrotica* was frequently observed in the closed floral chambers of *Nelumbo* during late afternoon hours. We suggest that *Diabrotica* actively seeks out closed flowers and, although not trapped within the flower, the flower does serve as a heat source for evening residence as has been documented for *N. nucifera* (Seymour, 2010). Some flowers chosen will be female and others bisexual. Such behavior, i.e., the active seeking out of new flowers every evening, would have the result of *Diabrotica* moving from bisexual flowers carrying pollen to female-phase flowers within a 24 h period and affecting cross-pollination; we realize, however, that self-pollination also remains a strong possibility because Nelumbo exhibits clonal growth.

That Chrysomelidae can be effective pollinators is illustrated in Tables 4, 5 ; and 6. Flowers open to pollination only on the first-day of anthesis did not differ statistically in mean fruit production from flowers open for the two days of anthesis. The most frequent visitor to first-day female-phase flowers was the Chrysomeldiae comprising 38% of the floral visitors, and *Dia-brotica* were as effective as halictid bees in transferring pollen to stigmas.

In conclusion, we suggest that while the assemblage of floral visitors to *Nelumbo lutea* is taxonomically broad, the floral characteristics seem to favor visitation and pollination by beetles and medium-sized bees such as halictids. Floral characteristics such as protogyny, movement of perianth parts, and formation of a floral chamber are typical for beetle pollinated flowers; floral thermogenicity is typical of flowers pollinated by beetles and flies, and serves to volatilize the main component of the floral scent 1,4-DMB, which is known to attract both Chrysomelidae and bees to flowers. Both beetles and bees have been noted as common floral visitors to *N. lutea* and are equally effective in transferring pollen to stigmas. We do, however, suggest the elevated floral temperatures due to thermoregulation encourage the behavior of chrysomelids to seek out flowers each afternoon as a heat source for evening residence and that the Chrysomelidae, with the interfloral search behavior just described, constitute an insect group capable of affecting cross-pollination.

We do not suggest that other insect visitors are incapable of transporting pollen or affecting pollination only that most insect visits are to bisexual-phase flowers with intrafloral pollen transfer being common and resulting in self-pollination. *Nelumbo lutea* is a clonal plant species and the area covered by a single genet may be extensive. In this case, many interfloral movements by any pollinator would still result in self-pollination via geitonogamy. Nevertheless, any insect group exhibiting a high propensity for interfloral movements would be most likely to move pollen between clones thereby affecting cross-pollination.

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SAMPLE **RESEARCH PROPOSAL 1**

Synthesis of Terpenoid Estrogen Precursors

Thesis, Purpose, Objective and Approach

Tamoxifen (common name is Nolvadex®) is one of the most popular preventative treatments for breast cancer. The drug stops or slows the growth of breast cancer cells present in the body by binding to the estrogen receptors. Tamoxifen is, therefore, considered an anti-estrogen in breast tissue. The effects of estrogen are mediated by the estrogen receptor functioning as a transcription factor. Estrogen receptors are over expressed in malignant breast lesions as opposed to normal tissue[1].

Breast cancer is both the most common malignancy in women worldwide as well as the leading cause ofcancer-related deaths in non-smoking women in the United States. Breast cancer can occur as a result of high estrogen levels, which can induce the proliferation of breast cancer cells. An excess amount of estrogen can also enhance the metastatic capability of breast cancer cells; the resultant disease spreads rapidly to other areas in the body. Tamoxifen is used to inhibit interactions between estrogen receptors and estrogen. However, tamoxifen is only partly selective in binding to estrogen receptors and, therefore, it also binds estrogen receptors associated with negative side effects. For example, tamoxifen is known to cause two different types of cancer that can develop in the uterus. The contradicting actions of Tamoxifen were reproduced in cell culture models[2].

Tamoxifen exemplifies the difficulty in developing an efficient preventative treatment for breast cancer. Our goal is to identify a molecule with binding activity to specific estrogen receptors associated with cancer prevention. We would like to preserve the positive effects estrogen has on the body. In the brain, for example, estrogen improves cognitive function. Estrogen also prevents bone loss, and lowers cholesterol in the liver. Also, this hormone helps keep the pelvic floor organs in place, and plays a role in retaining voluntary control of urinary excretions. Therefore, a treatment must be found that will maintain the positive functions of estrogen, while eliminating those effects that can lead to cancer[3].

Through the use of enzymatic engineering and synthetic chemistry new estrogen analogs that are expected to show novel activity towards estrogen receptors will be produced. For this approach, a linear terpenoid substrate will be synthesized that will then be cyclized to estrogen analogs by terpene cyclase enzymes. In order to find a suitable enzyme mutant that is capable of accepting the unnatural substrate, the substrate will be fed to a library of ~10^9 enzyme mutants. Once an enzyme is isolated that shows the desired activity, the unnatural estrogen analogs can be extracted and tested for efficiency. This class of enzymes has been studied extensively, and our laboratory focuses on tobacco epi-aristolochene synthase (TEAS), whose natural substrate is farnesyl-pyrophosphate[4].

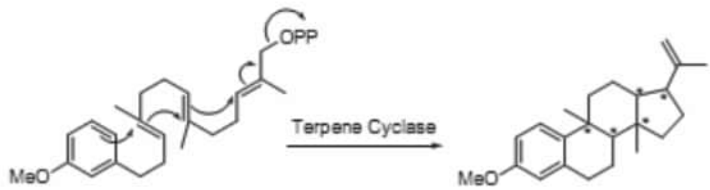

Figure 1. Potential enzymatic cyclization of an estrogen precursor

The cyclization reaction, as shown in figure 1, would most likely yield several different products, depending on how specific the terpene cyclase works and the type of residues that are attached to the substrate. Also, due to the many stereocenters that are observed in the final product, there would also be diversity in the stereochemistry of the molecule. The specific goal of my project is to synthesize the uncyclized terpenoid substrate that will be fed to the enzymes. The following will illustrate my responsibilities by describing methods I have used thus far.

Responsibility

A post-doctoral fellow in the Weiss laboratory planned the basic experimental designs presented in this proposal. For every experiment, first I review procedures found in publications. I then scale the reaction to the necessary amount, and run the experiment based on the different procedures outlined in the literature.

Once the reaction is complete and, depending on whether a work-up procedure is required, I isolate the desired product and purify it through column chromatography. An example of my responsibilities is demonstrated through the synthesis of a terpenoid estrogen precursor I worked on earlier this year. The synthesis of 1-methoxy-3-(4,8,12-trimethyl-trideca-3,7,11-trienyl)-benzene was attempted through the use of a sulfone group which would direct the addition of a benzylic group to farnesol. The final product was obtained after a series of four reactions, ending with the removal of the sulfone group. The first reaction involved a simple bromination of the hydroxyl group of the farnesol.

The bromine is installed, because it is needed as a leaving group. Attaching the sulfone group involved a nucleophilic substitution of the bromine with p-toluene sulfinic acid. The farnesylsulfone was deprotonated with n-butyl lithium α to the sulfone group. The carbanion was stabilized through the sulfur. Then 3-methoxybenzyl chloride was added and the farnesyl-benzyl-sulfone was formed through a nucleophilic attack (Figure 2). The removal of the sulfone proved to be a lot more challenging than expected. My attempts at removing the sulfone were unsatisfactory and were finished by Dr. Feld who also carried out the last steps to introduce the pyrophosphate leaving group.

During my summer research I will work on the synthesis of a library of unnatural estrogen precursors as shown in figure 3. This design will allow me to use simple propargyl precursors to form a library of various estrogen precursors with different types of substituents on the double bonds.

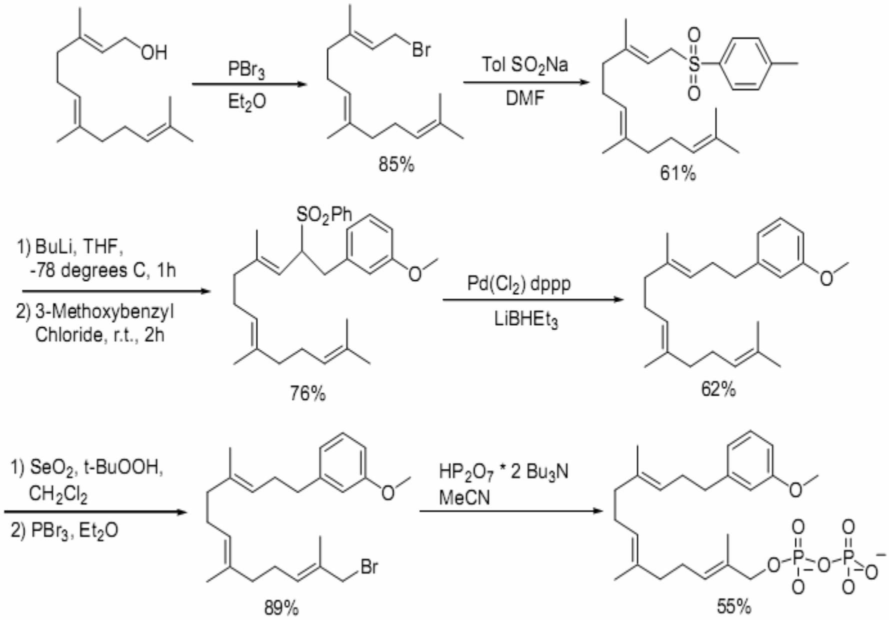

Figure 2. The figure above shows the complete procedural outline of the method attempted

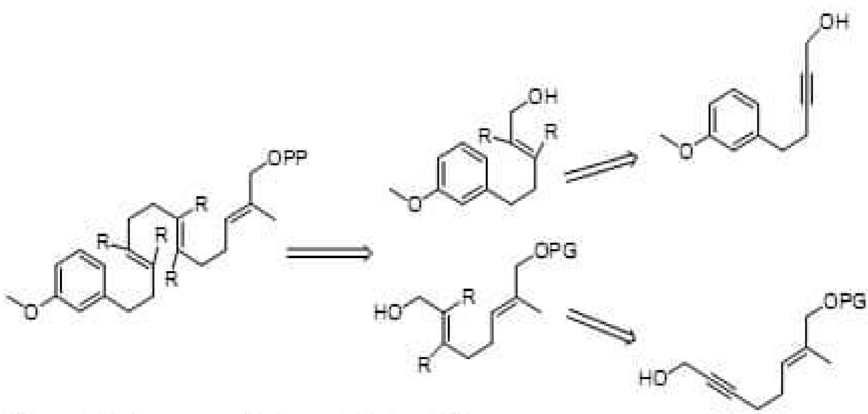

Figure 3. Retrosynthetic analysis of the estrogen precursor library.

The syntheses of the propargyl alcohols **A** and **B**[5] , as shown in figure 4, have been reported in the literature and have been worked on before by Dr. Feld and myself. Therefore, synthesis of the starting material is expected to proceed quickly. (Figure 4).

The triple bonds can then be reduced selectively to form either a vinyllic iodide[6] or stannane[7] (Figure 5). After this step, the two compounds will be coupled together by the same sulfone chemistry used above to create the desired analog precursors.

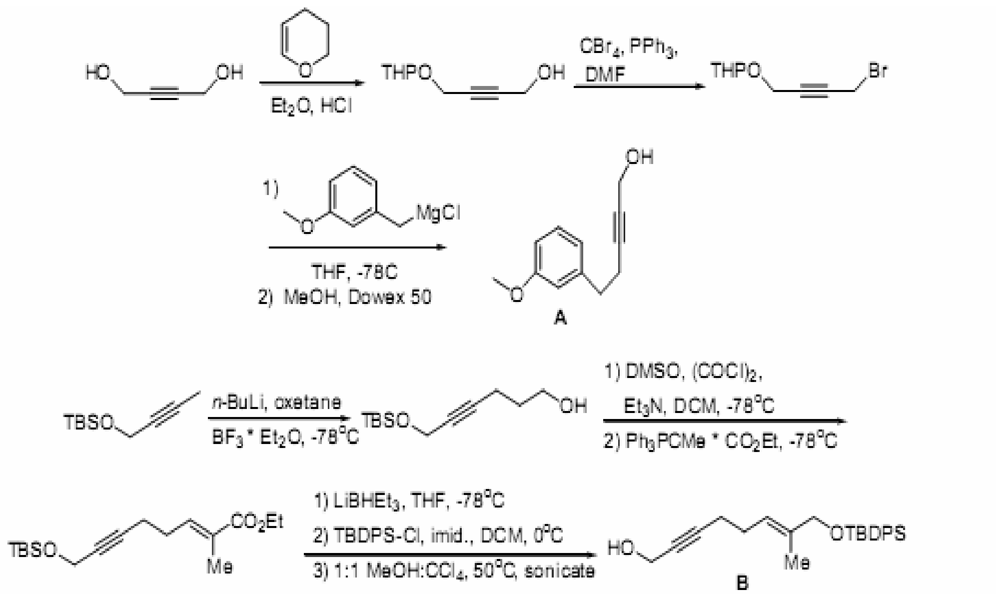

Figure 4. Synthesis of aromatic propargyl alcohol (A) and second propargyl alcohol (B)

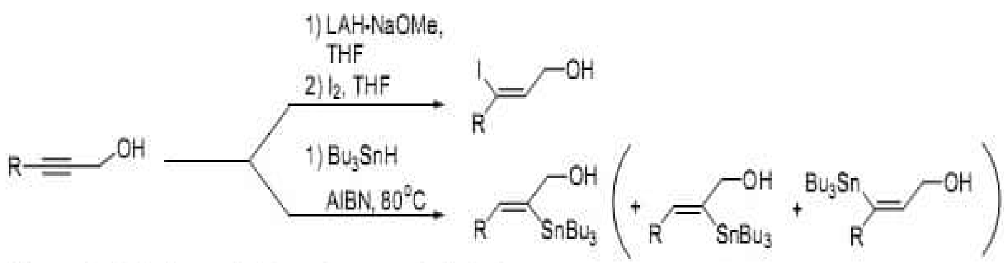

Figure 5. Selective reduction of propargyl alcohols

With the knowledge and experience that I have acquired in the past year, this synthesis is very manageable.

Timeline

The following table outlines the proposed schedule of experiments that will take place during the intensive ten-week period during the summer.

Week 1 – 3	Bring up the starting material as depicted in Figure 4.
Week 4	Selective reduction of triple bonds to form vinyl iodides and vinyl stannanes, shown in Figure 5.
Week 5 – 7	Introduction of different residues in the vinyllic position.
Week 8 – 10	Coupling of fragments to form a library of terpenoid estrogen precursors (Figure 3)

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SAMPLE RESEARCH PROPOSAL 2

Effect of Antibody to ß-amyloid on the Microglial Mediated Aß-induced Neurotoxicity

Introduction

Microglia are the phagocytes of the brain (McGeer and McGeer 2003), engulfing and ingesting cell wastes and any other foreign particles in an attempt to defend the brain against possible harm. Despite the beneficial capability of these phagocytic cells, there is much ongoing debate over whether "activated" microglia are beneficial or harmful in certain disease states.

Alzheimer's disease (AD), the most common form of dementia, is characterized by pathology including neuronal loss, β-amyloid (Aβ) plaques and neurofibrillary tangles (McGeer and McGeer, 2003). Clusters of activated microglia appear on the senile plaques of AD brain, while few, if any, are seen in similar regions of control brains (McGeer and McGeer, 2003), indicating a potential role for microglia in the disease, although it is unclear whether this role would be detrimental or protective or both under different conditions. There is considerable evidence that fibrillar Aβ-activated microglia produce neurotoxic material including proinflammatory cytokines, nitric oxide (NO), and reactive oxygen species (ROS), all inflammatory agents that consequently lead to neuronal damage. In addition to activated microglia, complement proteins are upregulated in AD. C1q, the recognition component of the classical complement pathway, has been found colocalized with the fibrillar plaques and C1q synthesis has been demonstrated to be induced in rat hippocampal slice cultures upon treatment with Aβ (Fan and Tenner, 2003).

The goal of this project is to determine if there is a difference in microglia-mediated neurotoxcity induced in the presence of MCSF and Aβ immune complex verses that induced in the presence of MCSF and Aβ alone. Although members of the Tenner Lab have shown convincing evidence of the neurotoxicity induced in the presence of Aβ and MCSF (M. Li, submitted for publishing), less is known about the interaction between Aβ-anti-Aβ immune complexes and MCSF. In addition, previous work done in the Tenner lab by Webster et al. involving anti-Aβ immune complexes demonstrated that the presence of C1q enhances microglial scavenger receptor-independent uptake of immune complexes composed of fAβ and suboptimal amounts of anti-Aβ Ab (2001). However, these analyses were performed after 30 minutes and no long-term effects on ingestion were studied. C1q's effect on neurotoxicty between MCSF and Aβ-anti-Aβ immune complexes at varying amounts of anti-Aβ has not been studied. Therefore, I plan to assess the levels of neurotoxicity induced by Aβ-anti-Aβ immune complexes in the presence and absence of MCSF, and compare that to the neurotoxicity induced by Aβ alone in the presence and absence of MCSF, and then finally assess the effect of C1q on the toxicity or modulation of toxicity by the presence of anti-Aβ resulting in the formation of immune complexes.

In general, antibodies are prevented from entering the brain by the blood-brain barrier (a tight cell layer that protects the brain from harmful substances in the bloodstream); however, others have shown that some antibody entered the brain of an APP transgenic mouse AD model immunized with Aβ and may have caused clearance of Aβ (Schenk et al., 1999). In the absence of antibody, Aβ uptake proceeds via the scavenger receptor (SR)-mediated pathway, while in the presence of anti-Aβ immune complexes, Aβ uptake proceeds via the Fc receptor (FcR)-mediated pathway (Paresce et al., 1996). Since the presence of antibody affects the method of uptake (Webster et al., 2001), I would like to know if this difference in uptake would also affect neurotoxicity.

In order to investigate these questions, I will first prepare Aβ-anti-Aβ immune complexes (IgG-fAβ) and verify that microglial ingestion is the same as demonstrated by Webster et al. (2001). Following this, we will verify the levels of neurotoxicity induced in the presence of both Aβ and MCSF and in the presence of Aβ itself. Next, we will determine if IgG-fAβ (with either high or low levels of antibody forming the complexes) affects neurotoxicity with and without the presence of MCSF. Finally, we will assess the effect of C1q bound complexes on neurotoxicity.

At the end of this research project, I hope we will have a better understanding of the effects of C1q and Aβ antibody on Aβ/MCSF microglial induced neurotoxicity. Since there are current studies involving the inoculation of anti-Aβ antibody as a possible treatment for Alzheimer's disease in this laboratory and others, this study will provide important information on the neurotoxicity involved in such a treatment and enable future researchers to be aware of the possible risks/advantages involved.

Materials and Methods

Formation of fAβ and Aβ-anti-Aβ Immune Complexes:

fAβ and Aβ-anti-Aβ immune complexes are formed as described by M. Li (submitted for publication).

Microglial Cell Culture:

Cortical tissue is obtained from 2-4-day-old Sprague Dawley rat pups and exposed to 0.25% trypsin/calcium-magnesium-free buffer (CMF) solution at 1 ml per brain for 10 min at 37˚C. Following this incubation, the trypsin is replaced with DMEM supplemented with 10% fetal calf serum (FBS) and the cells are centrifuged at 1200 rpm for 7 min. The tissue is then dissociated by titration using flame constricted Pasteur pipettes. After addition of DMEM-10%FBS and a second centrifugation (at same settings as above), the supernatant is removed and the pellet is resuspended to a final volume of 1ml DMEM-10%FBS per brain. Finally, 1ml of this tissue/DMEM solution is added to each of the poly-L-lysine coated flasks previously filled and incubated with 10ml DMEM-10%FBS. After 24 hours, 9 ml of the supernatant is replaced with fresh media. The microglia cells are collected after 7-10 days by shaking flasks using a rotary shaker at 140 rpm and 37˚C for 90 minutes, centrifugation at 1200 rpm for 7 min, and washing in neurobasal media to remove serum, and resuspending in NB/N2 media.

<u>*Flow Cytometric Assessment of Phagocytosis:*</u>

Microglia are obtained from flasks as described above and resuspended in NB/N2 media (this media differs from that used by Webster, et al, but is critical to support neurons in the subsequent neurotoxicity assay). SR ligands are added to cultures 25 minutes before addition of peptide to saturate microglial SR. Cells untreated are controls assessed in parallel to the SR-ligand treated cells. Following exposure to Aβ or Aβ-immune complexes for 30 min at 37˚C, microglia are washed twice with HBSS to remove unassociated fAβ and treated with 250μg/ml trypsin/EDTA for 10 min at 37 ˚C to eliminate surface-bound fAβ and to detach the cells from the culture surface. The trypsin reaction is stopped with 1 ml DMEM supplemented with 10% FBS and the wells are washed 2 times with 1ml DMEM-10%FBS. Microglia are then fixed in solution by exposure to 4% paraformaldehyde for 10 min, washed twice, and permeabilized by addition of 0.1% Triton X-100 (in PBS) for 5 min at room temperature. Cells are washed and resuspended in 250μl residual FACS buffer (HBSS + 0.1% BSA + 0.01% NaN3), followed by addition of 3 μg mouse monoclonal anti-Aβ antibody 4G8 and incubation at 4˚C for 1 hour. Cells are then washed twice at 4˚C and FITC-goat anti-mouse IgG F (ab') was added (3μg/250μl). After 30 min incubation at 4˚C, the cells are washed twice, resuspended in FACS buffer and cell-associated fluorescence is determined using FACSCalibur.

<u>*Neuronal Cell Culture:*</u>

Neuron cells are obtained from E18 Sprague-Dawley rat embroyos as described by M. Li (submitted for publication).

<u>Co-Cultures of Microglia and Cortical Neurons:</u>

Co-cultures are prepared by plating 1 x 105 microglial cells into each well of a 24-well plate previously plated with 50,000 neurons (used at 3 days in culture) in NB/N2. One hour later, co-cultures are treated with or without MCSF in the presence of fAβ and IgG, and in the presence or absence of C1q. After 72 hours, the media is collected for the nitrate assay and the cultures are fixed for immunocytochemistry.

<u>*Immunocytochemical Assay for an Analysis of Neurotoxicity:*</u>

Neurotoxicity is assessed as described by M. Li (submitted for publication).

Level of Preparation

While working in the Tenner lab for the last two quarters, I have been continuously performing microglial preps on rat pups. The primary microglia cells obtained through these procedures have been used successfully in cell culture models including various neurotoxicity and RPA experiments. I have observed and am able to perform the neuron cell prep, in addition to being trained to perform immunostaining of these neuron cells. I am currently in the process of learning Fluorescence Activated Cell Sorter (FACS) analysis and thus will be proficient at most, if not all, necessary techniques for this project by the start date.

Timeline

Experiment #1 (Week 1):

There will be six conditions involved here: (1) fAβ, (2) fAβ + IgG10 (prepared using 10μg/ml anti-Aβ Ab), (3) fAβ +IgG100 (prepared using 100μg/ml anti-Aβ Ab), (4) fAβ + Clq, (5) fAβ/Clq + IgG10, and (6) fAβ/Clq + IgG100. (Plus untreated control for background fluorescence.) Prepare Aβ-anti-Aβ immune complexes. Verify C1q's enhancement of IgG10-fAβ uptake by microglia at 2 μM fAβ at 30 min of exposure through FACS analysis as demonstrated by Webster et al. (2001).

Experiment #2 (Weeks 2&3):

Repeat experiment #1 at concentration of 10 μM fAβ (because neurotoxicity experiments are done at this concentration) and see if the results are the same as those of the lower concentration of amyloid.

Experiment #3 (Weeks 4&5):

Assess ingestion at times of 30 min, 2 hours, and 18 hours using the same conditions as experiment #2, while Karntipa Pisalyaput performs parallel co-cultures of microglia and cortical neurons to assess these treatments on neurotoxicity (at 48 and 72 hours). Neuron only cultures will be assayed in parallel to determine that any toxicity seen is microglia-mediated. I will also participate in the staining and be a second independent scorer of the neurotoxicity experiments.

Experiment #4 (Weeks 6&7) :

Repeat experiment #3 with the addition of MCSF.

Week 8:

Repeat any necessary experiments (using different concentrations of MCSF).

Weeks 9&10:

Complete data analysis and prepare my write-up and talk.

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APPENDIX 3

PEER REVIEW SHEETS

PEER REVIEW CHECKLIST FOR ARGUMENT ESSAY DRAFT

Read the essay through, quickly. Then read it again, with the following questions in mind. Please write extensive comments either on this form or/and in your workshop partner's draft where applicable.

1. Does this draft respond to the assignment?	
2. Is the thesis of the essay clearly stated? Underline the thesis on your workshop partner's draft. If it is implied only, write down what you perceive to be the thesis here.	
3. Are the needs of the audience kept in mind? For instance, do some concepts or words need to be defined? Is the evidence (examples, testimony of authorities, personal observations) clear and effective?	
4. Is any obvious evidence (or counter-evidence) overlooked?	
5. Can you accept the writer's assumptions? If not, why not? Please be honest and specific.	

6. Looking at each main body paragraph separately answer: a. What is its basic point? b. How does this paragraph relate to the essay's main idea or the previous paragraph? c. Should some paragraphs be deleted? Be divided into two or more paragraphs? Be combined? Be put elsewhere? d. Is each sentence clearly related to the sentence that precedes it and to the sentence that follows? e. Is each paragraph adequately developed? Are there sufficient details, perhaps brief quotations or paraphrases from credible sources?	I II III
7. Are the introductory and concluding paragraphs effective?	
8. What are the paper's main strengths?	
9. Make at least one specific suggestion that you think will assist the author to improve the paper	
10. Mechanics. Point out errors in spelling or grammar.	

PRESENTATION PEER REVIEW SHEET

Use the following scale to rate the presenter: 1 - very poor; 2 - not enough; 3 - average; 4 - good; 5 - excellent

Presenter's name	Reviewer's name	
Paper topic		
Content	relevance of the topic	
	was the key idea clear?	
	reference to literature and scientific principles	
	appropriateness of the supporting evidence	
	explanation of specific terms	
Organisation	overall structure	
	research problem and objectives clearly stated	
	results clearly explained including their implications	
	conclusions related to objectives	
Delivery	style and confidence of delivery	
	appropriate pace	
	voice quality/ intonation	
	audience rapport	
	time management	
	body language	
	grammar and vocabulary	
	dealing with questions	
audio-visual support	appropriateness of diagrams/ tables/ graphs/ videos, etc.	
	clear legible images	
	right amount of material per slide	
	clear link between images and oral presentation	
	contribution of the slide design and layout to the effectiveness of the presentation	

What is the take home message of the presentation?

Describe one strength of the presentation.

What would you have done differently if you were the presenter?

Did the speaker achieve his goal?

APPENDIX 4

CSE DOCUMENTATION SYSTEMS

Though scientific publications document sources in similar ways, the details of presenting source information vary from journal to journal. Often publications provide prospective authors with style sheets that outline formats for presenting sources. Before submitting an article to a scientific publication, you should request its style sheet. If one is not available, examine a copy of the publication to see how sources are documented. When writing for a science course, check with your instructor about how to cite and list your sources.

Most biologists, zoologists, earth scientists, geneticists, and other scientists use one of three systems of documentation specified by the Council of Science Editors in Scientific Style and Format: The CSE Manual for Authors, Editors, and Publishers (7th ed., 2006).

In the ***CSE name-year system***, the author of the source is named in the text and the date is given in parentheses.

In the ***CSE citation-sequence system***, each source cited in the paper is given a number the first time it appears in the text. Anytime the source is referred to again, the text is marked with the same number. At the end of the paper, a list of references provides full publication information for each numbered source. Entries in the reference list are numbered in the order in which they are mentioned in the paper.

In the CSE citation-name system, the list of references is first put in alphabetical order and then the entries are numbered in that order. Those numbers are used in the text to cite the sources from the list. This section describes formatting of in-text citations and the reference list in all three systems and gives specific models for entries in a citation-sequence reference list.

CSE IN-TEXT CITATIONS

In the text of a paper using the citation-sequence or citation-name system, the source is referenced by a superscript number.

In-text citation:

Scientists are beginning to question the validity of linking genes to a number of human traits and disorders [1].

At the end of the paper, on a page titled References or Cited References, the source is fully identified according to CSE style.

Entry in the reference list:

1. Horgan J. Eugenics revisited. Sci Am. 1993; 268(6):122-130.

In the name-year system, the author's name and the date are given in parentheses in the text of the paper. Alternatively, the author's name can be given in a signal phrase and the date in parentheses.

This species was not listed in early floras of New York; however, it was reported in a botanical survey of Chenango County (Osiecki and Smith 1985).

Smith (2003), studying three species of tree frogs in South Carolina, was the first to observe...

CSE REFERENCE LIST

Basic format. Center the title References (or Cited References) and then list the works you have cited in the paper; do not include other works you may have read. Double-space throughout.

Organization of the list. In the citation-sequence system, number the entries in the order in which they appear in the text. In the citation-name system, first alphabetize all the entries by authors' last names (or by organization name or by title for a work with no author). Then number the entries in the order in which they appear in the list. In both systems, use the number in the reference list every time you refer to the corresponding source in the paper. Make the entire entry flush with the left margin.

In the name-year system, the entries in the reference list are not numbered. They are alphabetized by authors' last names (or by organization name or by title for a work with no author). The year is placed after the last author's name, followed by a period. To convert the models shown here to the name-year system, omit the number and move the date of publication after the last author's name.

Authors' names. List authors' names last name first. Use initials for first and middle names, with no periods after the initials and no space between them. Do not use a comma between the last name and the initials. Use all authors' names if a work has up to ten authors; for a work with eleven or more authors, list the first ten names followed by a comma and "et al." (for "and others").

Titles of books and articles. Capitalize only the first word in the title of a book or article (and all proper nouns). Do not underline or italicize the titles of books; do not place titles of articles in quotation marks.

Titles of journals. Abbreviate titles of journals that consist of more than one word. Omit the words 'the' and 'of'; do not use apostrophes. Capitalize all the words or abbreviated words in the title; do not underline or italicize the title: Science, Sci Am, N Engl J Med, Womens Health.

Page ranges. Do not abbreviate page ranges for articles in journals or periodicals and for chapters in edited volumes. When an article appears on discontinuous pages, list all pages or page ranges, separated by commas: 145-149, 162-174. For chapters in edited volumes, use the abbreviation "p." before the numbers (p. 63-90).

Books

1. Basic format for a book. After the author(s) and title, give the place of publication, the name of the publisher, and the date of publication.

1. Melchias G. Biodiversity and conservation. Enfield (NH): Science; 2001.

2. Two or more authors. List the authors in the order in which they appear on the title page. For a work with two to ten authors, list all the authors. For eleven or more authors, list the first ten followed by "et al." (for "and others").

2. Ennos R, Sheffield E. Plant life. Boston: Blackwell Scientific; 2000.

3. Edition other than the first. Include the number of the edition after the title.

3. Mai J, Paxinos G, Assheuer J. Atlas of the human brain. 2^{nd} ed. Burlington (MA): Elsevier; 2004.

4. Article or chapter in an edited volume Begin with the name of the author and the title of the article or chapter. Then write "In:" and name the editor or editors, followed by a comma and the word "editor" or "editors." Place the title of the book and publication information next. End with the page numbers on which the article or chapter appears.

4. Underwood AJ, Chapman MG. Intertidal ecosystems. In: Levin SA, editor. Encyclopedia of biodiversity. Vol. 3. San Diego: Academic Press; 2000. P. 485-499.

Articles

5. Article in a magazine. Provide the year, month, and day (for weekly publications), followed by the page numbers of the article.

5. Stevens MH. Heavenly harbingers. Smithsonian. 2001 Nov:20, 22.

6. Article in a journal. After the author(s) and the title of the article, give the journal title, the year, the volume number, the issue number if there is one (in parentheses), and the page numbers on which the article appears.

6. Gulbins E, Lang F. Pathogens, host-cell invasion and disease. Am Sci. 2001; 89(5):406-413.

7. Article in a newspaper. After the name of the newspaper, give the edition name in parentheses, the date of publication, the section letter (or number), the page number, and the column number. If the newspaper does not have section designations, use a colon between the date and the page number.

7. O'Neil J. A closer look at medical marijuana. New York Times (National Ed.). 2001 Jul 17; Sect. D:6 (col. 4).

8. Article with multiple authors. For a work with up to ten authors, list the names of all authors. For a work with eleven or more authors, list the first ten names followed by a comma and "et al." (for "and others").

8. Longini IM Jr, Halloran ME, Nizam A, Yang Y. Containing pandemic influenza with antiviral agents. Am J Epidemiol. 2004; 159(7):623-633.

9. Article with a corporate author. When a work has a corporate author, begin with the authoring organization, followed by the article title, journal title, and all other publication information.

9. International Committee of Medical Journal Editors. Clinical trial registration: a statement from the International Committee of Medical Journal Editors. JAMA. 2004; 292(11):1363-1364.

In the name-year system, a familiar abbreviation for an organization is given in brackets at the beginning of the entry: [NCI] National Cancer Institute. 2004. The abbreviation is used in the in-text citation: (NCI 2004).

Electronic sources

CSE guidelines for Web sites and subscription services require publication information as for books: city, publisher, and publication date. This information can usually be found on the home page of a Web site and in a copyright link in a subscription service. In addition, include an update date if one is available and your date of access. Do not use a period at the end of a URL unless the URL ends in a slash.

10. Home page of a Web site. Begin with the author, whether an individual or an organization. Include the title of the home page (if it is different from the author's name), followed in brackets by the word "Internet." Provide the place of publication, the publisher (or the site's sponsor), and the date of publication. Include the copyright date if no date of publication is given or if the publication date and the copyright date are different: 2010, c2009. Include in brackets the date the page was last modified or updated and the date you accessed the site: [modified 2009 Mar 14; cited 2010 Feb 3]. Use the phrase "Available from:" followed by the URL.

10. American Society of Gene and Cell Therapy [Internet]. Milwaukee (WI): The Society; c2000-2010 [modified 2010 Jan 8; cited 2010 Jan 16]. Available from: http://www.asgt.org/.

11. Short work from a Web site. If the short work does not have an author or if the author is the same as the author of the site, begin the citation as for a home page. After the publication information, give the title of the short work, the date of publication or most recent update, if available, and the date of access. Indicate in brackets the number or estimated number of pages, screens, paragraphs, lines, or bytes: about 5 p., about 3 screens, 12 paragraphs, 26 lines, 125K bytes. End the citation with the phrase "Available from:" followed by the URL.

11. Cleveland Clinic. The Cleveland Clinic Health Information Center [Internet]. Cleveland (OH): The Clinic; c2006. Smoking cessation; 2009 [cited 2010 Feb 8]; [about 3 screens]. Available from: http://www.clevelandclinic.org/services/smoking_cessation/hic_quitting_smoking.aspx

If the short work has an author different from the author of the site, begin with the author and title of the short work, followed by the word "In:" and the home page information as in item 10. End with the URL for the short work.

12. Online book. To cite an online book, follow the instructions for a home page, but include the description "Internet" in brackets following the title.

12. Wilson DE, Reeder DM, editors. Mammal species of the world [Internet]. Washington (DC): Smithsonian Institution Press; 3rd ed. Baltimore (MD): Johns Hopkins University Press; c2005 [cited 2007 Oct 14]; [about 200 screens]. Available from: http://vertebrates.si.edu/mammals/msw/.

If you are referring to a specific chapter or section in an online book, begin the citation with the author and the title of the specific part. Follow with the word "In:" and the author, editor, title, and publication information for the entire book. End with access information about the specific part.

12. Olson S. The path to a PhD. In: Jarmul D, editor. Beyond bio 101: the transformation of undergraduate biology education [Internet]. Chevy Chase (MD): Howard Hughes Medical Institute; c2001 [cited 2009 Nov 19]; [about 2 screens]. Available from: http://www.hhmi.org/beyondbio101/phdpath.htm

13. Article in an online periodical. Begin with the name of the author and the title of the article. Include the name of the journal, followed by the word "Internet" in brackets. Give the date of publication or the copyright date. Include in brackets the date the article was updated or modified, if any, and the date you accessed it, followed by a semicolon. Then provide the volume, issue, and page numbers. If the article is unpaginated, include in brackets the number or an estimated number of pages, screens, paragraphs, lines, or bytes. Write "Available from:" and the URL.

13. Isaacs FJ, Blake WJ, Collins JJ. Signal processing in single cells. Science [Internet]. 2005 Mar 25 [cited 2009 Jun 17]; 307(5717): 1886-1888. Available from: http://www.sciencemag.org/cgi/content/full/307/5717/1886

14. Work from a subscription service. CSE does not provide guidelines for an article accessed through a subscription service, such as InfoTrac or EBSCOhost. The guidelines presented here are based on CSE's models for an article in an online periodical and for a complete database.

Begin with information about the online article, as in item 13. Follow with the name of the database, the place of publication, the publisher, and the date of publication or the copyright date. End with the phrase "Available from:" followed by the URL for the database. Include an article or document number, if the database assigns one, after the URL.

14. Cantor RM, Kono N, Duvall JA, Alvarez-Retuerto A, Stone JL, Alarcon M, Nelson SF, Geschwind DH. Replication of autism linkage: fine-mapping peak at 17q21. Am J Hum Genet [Internet]. 2005 [cited 2009 Jun 17]; 76(6):1050-1056. Expanded Academic ASAP. Farmington Hills (MI): Thomson Gale; c2005. Available from: http://web4.infotrac.galegroup.com/. Document No.: A133015879.

Other sources (print and online)

15. Government report. Begin with the name of the agency and, in parentheses, the country of origin if it is not part of the agency name. Next include the title of the report, a description of the report (if any), the place of publication, the publisher, and the date of publication. Give any relevant identifying information, such as a document number, and then the phrase "Available from:" followed by the name, city, and state of the organization that makes the report available or the URL for an online source.

15. National Institute on Drug Abuse (US). Inhalant abuse. Research Report Series. Bethesda (MD): National Institutes of Health (US); 2005 Mar. NIH Pub. No.: 00-3818. Available from: National Clearinghouse on Alcohol and Drug Information, Rockville, MD 20852.

15. National Institute on Drug Abuse (US). Inhalant abuse [Internet]. Research Report Series. Bethesda (MD): National Institutes of Health (US); 2005 Mar [cited 2005 Jun 23]; [about 13 screens]. NIH Pub. No.: 00-3818. Available from: http://www.drugabuse.gov/ResearchReports/Inhalants/Inhalants.html

In the name-year system, begin with the abbreviation of the organization, if any, in brackets. (You will use the abbreviation in your in-text citations.) Use the complete name of the organization when you alphabetize the reference list.

[NIDA] National Institute on Drug Abuse (US). 2005 Mar. Inhalant abuse. . . .

16. Unpublished dissertation or thesis. After the author and title of the work, indicate the type of work in brackets. List the city and state of the institution granting the degree, followed by the name of the institution and the date of the degree. Include an availability statement if the work is archived somewhere other than the sponsoring university's library (for example: Available from: University Microfilms, Ann Arbor, MI).

16. Warner DA. Phenotypes and survival of hatchling lizards [master's thesis]. Blacksburg: Virginia Polytechnic Institute and State University; 2001 Jan 16.

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You can find more information about CSE documentation and formatting on this website ***http://bcs.bedfordstmartins.co m/resdoc5e/RES5ech11o.html***

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ACADEMIC GLOSSARY

Abbreviation *n*	A shortened form of a word or phrase
Abstract *n*	A *summary* of a work's contents. An abstract usually appears at the beginning of a *scholarly* or *technical article*
Academic communication	various forms of spoken and written discourse taking place in the context of higher education
Academic conference	A formalized event where scientists present their research results in speeches, *workshops*, posters or by other means
Academic essay	A specific writing *genre* used by *scholars* and students to advance ideas and persuade by reasoned *discourse*
Academic writing	The forms of *expository* and argumentative prose used by university students and researchers to convey a body of information about a particular subject. Academic writing is expected to be precise, semi-formal, impersonal, and objective.
Acknowledgement	An expression of thanks or a token of appreciation
Active reader	Someone who effectively constructs meaning from text (i.e., previews, questions, uses prior knowledge, monitors understanding, makes connections, synthesizes)
Ambiguous *adj*	Open to more than one interpretation
Analysis *n* (pl analyses)	Identification and evaluation of *data*, material, and *sources* for quality of content, validity, credibility and relevance
Analyze *v*	To examine something in great detail in order to understand it better or discover more about it
Anecdote *n*	A brief interesting or amusing life story used to make a point
Annotated bibliography	A list of *sources* that gives the publication information and a short description — or *annotation* — for each source
Annotation *n*	A critical or explanatory note; a commentary
Appendix *n* (pl appendices)	A body of separate additional material at the end of a book, paper, etc., esp. one that is documentary or explanatory
Apply *v*	To bring into action; use; employ
Argument *n*	One of the traditional modes of *discourse* using reasons or evidence to support a *claim* or opinion
Article *n*	A short work of nonfiction that typically appears in a magazine, newspaper, or book. Unlike essays, which often highlight the subjective impressions of the author, articles are usually written from an objective point of view

Audience *n*	The part of the general public interested in a *source* of information; the listeners or spectators at a speech or performance, or the intended readership for a piece of writing
Bibliography *n*	(1) A list of *sources*, usually appearing at the end of a *research paper*, an *article*, a book, or a chapter in a book. The list documents sources used in the work and points out sources that might be useful for further research. Entries provide publication information so that interested readers can track down and examine sources for themselves. (2) A list of recommended readings on a given topic, usually sorted into subcategories.
Block quotation	A *direct quotation* that is not placed inside *quotation marks* but instead is set off from the rest of a text by starting it on a new line and *indenting* it from the left *margin*
Blog *n*	A blog (short for *Weblog*) is a site that contains dated text or multimedia entries usually written and maintained by one person, with comments contributed by readers.
Body (e.g. of an essay) *n*	The part of an essay, report, or speech that explains and develops a main idea (or thesis)
Book review	A critical analysis of a book
Brainstorming *n*	In *composition*, an invention and discovery strategy in which the writer collaborates with others to explore topics, develop ideas, and/or propose solutions to a problem
Chart *n*	A sheet presenting information in the form of graphs or tables
Citation *n*	A reference to a book, an *article*, a Web page, or another *source* that provides enough information about the source to allow a reader to retrieve it.
Cite *n*, *v*	1) A shortened form of *citation* 2) To provide a *reference* to a *source*
Claim *n*, *v*	1) A statement of something as a fact; an assertion of truth 2) To state to be true, especially when open to question
Clarity *n*	A characteristic of a speech or a prose *composition* that communicates effectively with its intended *audience*
Clustering *n*	In *composition*, a discovery strategy in which the writer groups ideas in a nonlinear fashion, using lines and circles to indicate relationships
Coherence *n*	The logical connections that readers or listeners perceive in a written or oral text
Cohesion *n*	The use of repetition, *transitional* expressions, and other devices (cohesive cues) to guide readers and show how the parts of a *composition* relate to one other
Collaboration *n*	The ability to work effectively with diverse teams; be helpful and make necessary compromises to accomplish a common goal

Collaborative writing	Two or more persons working together to produce a written document
Common knowledge	Knowledge that is known by everyone or nearly everyone which does not need to be cited
Communicative competence	A language user's grammatical knowledge of syntax, morphology, phonology and the like, as well as social knowledge about how and when to use utterances appropriately
Communication *n*	The successful transmission of information through a common system of symbols, signs, behavior, speech, writing, or signals
Composition *n*	1) The process of putting words and sentences together in conventional patterns 2) An essay, usually brief and written for training purposes
Computer literacy	The knowledge of terminology and range of skills required to successfully use computers and other devices associated with computers
Concept map (concept web)	A type of graphic organizer - a diagram that illustrates the relationship among concepts
Concept mapping	*see* Clustering
Concise *adj*	Expressing much in few words; clear and succinct
Concluding sentence	Usually the last sentence in a paragraph that summarizes the main point(s) of the paragraph
Conclusion *n*	The sentences or paragraphs that bring a speech, essay, report, or book to a satisfying and logical end
Conference *n*	A large formal meeting where a lot of people discuss important matters such as business, politics, or science, esp. for several days
Conference proceedings	the collection of academic papers published in the context of an *academic conference*
Conference proposal	A form of *academic writing*, a proposal submitted by researchers in order to be permitted to participate in an *academic conference* and present their research findings
Creative thinking	The ability or power used to produce original thoughts and ideas based upon reasoning and judgment
Critical essay	A *composition* that offers an analysis, interpretation, and/or evaluation of a text
Critical thinking	The ability to acquire information, analyze and evaluate it, and reach a conclusion or answer by using logic and reasoning skills
Critique *n*	a formal analysis and evaluation of a text, production, or performance
Datum *n* (*pl* data)	Factual information, especially information organized for analysis or used to reason or make decisions
Deviation *n*	The difference between an observed value and the expected value of a variable or function

Direct quotation	A report of the exact words of an author or speaker. Unlike an *indirect quotation*, a direct quotation is placed inside *quotation marks*
Discipline *n*	An academic field of study, a branch of knowledge or teaching
Discourse *n*	The use of spoken or written language in a social context or a unit of language longer than a sentence
Discourse community	A term used in composition studies and sociolinguistics for a group of people who share certain language-using practices
Dissertation *n*	A treatise advancing a new point of view resulting from *research*; usually a requirement for an advanced academic degree
Documentation *n*	The process of providing *evidence* (including both *primary* and *secondary sources*) in a research paper
Draft *n*	A version of a piece of writing, often an early version in need of *revision* and *editing*
Editing *n*	A stage of the writing process in which a writer or editor strives to improve a *draft* by correcting errors and by making words and sentences clearer, more precise, and more effective
Empirical *adj*	Relying on or derived from *observation* or *experiment*
Endnote *n*	A *reference*, explanation, or comment placed at the end of an *article*, chapter, or book
Essay *n*	A brief, non-fiction composition that describes, clarifies, argues, or analyzes a subject
Evidence *n*	Facts, figures, details, *quotations*, or other sources of *data* and information that provide support for *claims* or an analysis that can be evaluated by others
Experiment *n*	A test under controlled conditions that is made to demonstrate a known truth, examine the validity of a *hypothesis*, or determine the efficacy of something previously untried
Expository *adj*	A type of statement or *composition* intended to give information about (or an explanation of) an issue, subject, method, or idea
Fallacious reasoning	Unsound reasoning or errors in argument or use of deception
Figurative language	Non-literal language containing words and phrases that require a reader to make inferences to create a more vivid image or real experience
Footnote *n*	A *reference*, explanation, or comment placed below the main text on a printed page
Freewriting *n*	A discovery (or *prewriting*) strategy intended to encourage the development of ideas without concern for the conventional rules of writing
Grant *n*	A giving of funds for a specific purpose (e.g. for *research*)
Grant proposal	A formal proposal submitted to a government or civilian entity that outlines a proposed project, shows budgetary requirements and requests monetary assistance in the form of a *grant*

Genre *n*	Any form of *communication*, whether written or spoken, based on some set of stylistic criteria, characterized by a specific format, structure and sphere of application
Graph *n*	A pictorial device, such as a pie chart or bar graph, used to illustrate quantitative relationships
Heading *n*	A brief descriptive word or phrase that introduces or summarizes a document or a section within a document
Hypothesis *n* (*pl.* hypotheses)	An idea that is suggested as an explanation for something, but that has not yet been proved to be true
Indirect quotation	A *paraphrase* of someone else's words. An *indirect quotation* (unlike a direct quotation) is not placed in *quotation marks*
Inference *n*	A logical guess based on *evidence* and prior knowledge
Innovation *n*	An improvement of existing technological product, system, or method of doing something
Indenting *n*	The blank space between a *margin* and the beginning of a line of text
In-text (pare*n*thetical) citation	The *citation* that appears at the end of the sentence or *paragraph* in the body of a paper with the name of the *source* enclosed in *parentheses*
Introduction (i*n*troductory paragraph)	The opening of an essay or speech, which typically identifies the topic, arouses interest, and prepares the *audience* for the development of the *thesis*
Jargon *n*	The specialized language of a professional, occupational, or other group, often meaningless to outsiders
Journal *n*	A type of periodical usually sold by subscription and containing *articles* written for specialized or *scholarly audiences*
Laboratory notebook	The primary permanent record of a researcher's laboratory work
Learning log	A personalized educational tool, usually in the form of a notebook, used for taking notes, responding to reading, recording one's learning experiences, and other kinds of input
Literacy *n*	The ability to read and write
Literature review	An *article* or paper describing published *research* on a particular topic. The purpose of a literature review (sometimes called a *review article*) is to select the most important publications on the topic, sort them into categories, and comment on them to provide a quick overview of leading *scholarship* in that area. Published articles often include a literature review section to place their research in the context of other work in the field
Margin *n*	The part of a page outside the main body of text
Model *n*	a visual, mathematical, or three-dimensional representation in detail of an object or design, often smaller than the original

Note-taking *n*	The practice of writing down or otherwise recording key points of information
Objectivity *n*	Judgment based on observable phenomena and uninfluenced by emotions or personal prejudices
Observation *n*	The act of noting and recording something, such as a phenomenon, with instruments
Outline *n*	A plan for a writing project or speech. An outline is usually in the form of a list divided into *headings* and *subheadings* that distinguish main points from supporting points
Panel presentation	A form of *presentation* in a small group in which the individual members interact and present differing viewpoints on a debatable topic
Paragraph *n*	A group of closely related sentences that develop a central idea
Paraphrase *n*	A restatement of a text in another form or other words
Parenthesis *n* (*pl.* parentheses)	Either or both of the upright curved lines, ( ), used to mark off explanatory or qualifying remarks in writing
Parenthetical reference	*Reference provided in parentheses*
Peer review	1) Part of the publication process for *scholarly* publications in which a group of experts examines a document to determine whether it is worthy of publication. Journals and other publications use a peer review process — usually arranged so that reviewers do not know who the author of the document is — to *assess articles* for quality and relevance. 2) Examination and critical evaluation of work done by one's peers (e.g. classmates) such as an *essay* or *presentation*.
Plagiarism *n*	The unattributed use of a *source* of information that is not considered *common knowledge*. In general, the following acts are considered plagiarism: (1) failing to cite quotations or borrowed ideas, (2) failing to enclose borrowed language in *quotation marks*, (3) failing to put *summaries* or *paraphrases* in your own words, and (4) submitting someone else's work as your own
Poster *n*	Any piece of printed paper designed to be attached to a wall or vertical surface. Typically posters include both textual and graphic elements. Posters are used in academia to promote and explain research work
Poster presentation	The *presentation* of *research* information by an individual or representatives of research teams at a congress or *conference* with an academic or professional focus. Presentations usually consist of affixing the research *poster* to a portable wall with the researcher in attendance answering questions posed by passing colleagues
Precision *n*	Mechanical or scientific exactness
Presentation *n*	A verbal report presented with illustrative material, such as slides, graphs, etc.

Prewriting *n*	Any activity that helps a writer think about a *topic*, determine a purpose, analyze an *audience*, and prepare to write
Primary source	An original *source*, such as a speech, a diary, a novel, a legislative bill, a laboratory study, a field research report, or an eyewitness account. In the sciences, reports of new research written by the scientists who conducted it are considered primary sources
Quotation *n*	The reproduction of the words of a speaker or writer
Quotation marks	Punctuation marks (“curly” or “straight”) used primarily to identify the beginning and end of a passage attributed to another *source* and repeated word for word
Reading response journal	A learning tool in the form of a notebook where students record their feelings, responses and reactions to reading texts. It is useful for promoting opinion making, value judgments, and *critical thinking*
Refereed publication	A publication for which every submission is screened through a peer *review process*. Refereed publications are considered authoritative because experts have reviewed the material in advance of publication to determine its quality
Reference *n*	A note in a publication referring the reader to another passage or *source*
Relevant ideas	Any thoughts, conceptions, or notions pertinent to a particular topic or activity
Research *n*	The collection and evaluation of information about a particular subject
Research paper	1) A form of *academic writing*, usually between five and fifteen pages long, composed by students in colleges and universities. 2) A *scholarly article* that contains the results of original research or an evaluation of research conducted by others.
Research proposal	A document written by a researcher that provides a detailed description of the proposed program. It is like an *outline* of the entire research process that gives a reader a summary of the information discussed in a project
Review *n*	A report or *essay* giving a critical estimate of a work or performance
Review article	see Literature review
Revision *n*	The process of rereading a text and making changes (in content, organization, sentence structures, and word choice) to improve it
Rhetoric *n*	The skill or art of speaking or writing effectively for a specific purpose
Sample *n*	A small part of or a selection from something, intended to show the quality, style, or nature of the whole; specimen

Scholar *n*	A specialist in a given branch of knowledge
Scholarly *adj*	Often used to describe books, periodicals, or *articles* that are written for a specialized *audience* of academics or researchers. These sources are generally formal in style and include *references* to other published sources
Scholarly journal	A journal that is primarily addressed to *scholars*, often focusing on a particular discipline. Scholarly journals are often *refereed publications* and thus considered authoritative. Articles in scholarly journals usually are substantial in length, use specialized language, contain *footnotes* or *endnotes*, and are written by academic researchers
Scholarship *n*	1) An amount of money that is given to someone to help pay for their education 2) The knowledge, work, or methods involved in serious studying
Science writing	1) Writing about scientific subject matter, often in a non-technical manner for an *audience* of non-scientists (a form of journalism) *2) Scientific writing*
Scientific discourse	The processes and methods used to communicate and debate scientific information
Scientific conference	See *Academic conference*
Scientific writing	Writing that reports scientific *observations* and results in a manner governed by specific conventions (a form of *technical writing*)
Search engine	A program that allows users to search for material on the Internet or on a Web site.
Secondary source	A *source* that comments on, analyzes, or otherwise relies on *primary sources*. An article in a newspaper that reports on a scientific discovery or a book that analyzes a writer's work is a secondary source
Source *n*	Any person, book, organization, etc., from which information, *evidence*, etc., is obtained
Subheading *n*	The *heading* or *title* of a subdivision or subsection of a printed work
Subjectivity *n*	Judgment based on individual personal impressions and feelings and opinions rather than external facts
Summary *n*	A shortened version of a text that highlights its key points
Supporting sentence	A sentence or a number of sentences following a *topic sentence* that develop the main idea with specific details
Table *n*	An orderly arrangement of *data*, especially one in which the data are arranged in columns and rows in an essentially rectangular form
Technical writing	Written communications done on the job, especially in fields with specialized vocabularies, such as science, engineering, technology, and the health sciences

Technology literacy	The ability to use, manage, understand and assess technology
Thesis *n*	1) The main idea of an essay, report, speech, or *research paper*, sometimes written as a single declarative sentence known as a *thesis statement* *2) a dissertation* resulting from original *research*, esp. when submitted by a candidate for a degree or diploma
Thesis statement	A sentence in an *essay*, report, *research paper*, or speech that appears in the *introductory paragraph* and identifies the main idea and/or central purpose of the text
Title *n*	A word or phrase given to a text (an *essay*, *article*, chapter, report, or other work) to identify the subject, attract the reader's attention, and forecast the tone and substance of the writing to follow
Title page	The page at the beginning of a volume (a book, paper, etc.) that bears the *title,* author's name, and other relevant information about the text
Topic *n*	The particular issue or idea that serves as the subject of a *paragraph*, *essay*, report, or speech
Topic sentence	A sentence, sometimes at the beginning of a *paragraph*, that states or suggests the main idea (or *topic*) of a passage
Transition *n*	The connection (a word, phrase, clause, sentence, or entire *paragraph*) between two parts of a piece of writing, contributing to *cohesion*
Verbosity *n*	excessive use of words
Visual *n*	A picture, chart, or other presentation that appeals to the sense of sight, used in promotion or for illustration or narration
Weblog *n*	See *Blog*
Workshop *n*	An educational seminar or series of meetings emphasizing interaction and exchange of information among a usually small number of participants
Writing process	The series of overlapping steps that most writers follow in composing texts

НАВЧАЛЬНЕ ВИДАННЯ

МИКИТЕНКО Наталія Олександрівна
КОЗОЛУП Марія Степанівна
РОЖАК Наталія Володимирівна

Основи англомовної академічної комунікації для студентів та аспірантів природничих спеціальностей

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про внесення суб'єкта видавничої справи
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