***All August 2010 additions are in red font.**

FROM Merritt Writing Program Assessment Plan Summary Chart

Distributed to all MWP faculty via UCM CROPS announcements on August 2010 in preparation for MWP orientation

CORE 100-equivalent WP courses

Summary of Activities: During April 2009, WRI 116 faculty met to review High-Middle-Low samples of an aligned Watson & Crick assignment and to draft a scientific literacy rubric. This rubric's focus attends to the Self and Society GE outcome, as this aligned assignment asks students to analyze the ways in which Watson and Crick contextualize their argument amongst others. Watson and Crick's narrative illustrates the ways in which a scientific community responds to audiences, contexts, and social norms. As the WRI 116 textbook, Penrose's *Writing in the Sciences*, repeatedly emphasizes, science is a social enterprise "shaped by the values of the dominant culture in which scientists participate and live, sharing many of its assumptions, goals, biases and problems" (6). The UC Merced general education learning outcomes that these activities respond to are:

> **Self and Society**: To understand and value diverse perspectives in both the global and community contexts of modern society in order to work knowledgeably and effectively in an ethnically and culturally rich setting.
>
> **Scientific Literacy**: To have a functional understanding of scientific, technological and quantitative information, and to know both how to interpret scientific information and effectively apply quantitative tools.

During July 2009, Mary Soltis and Anne Zanzucchi identified two sample texts for pre and post reading assessment-focused workshop activity, focused on science in a social context. These samples texts were adopted from *Fields of Reading: Motives for Writing* (Eds. Comley, Hamilton, and Klaus). All WRI 116: Writing in the Natural Sciences and WRI 119: Writing in Engineering faculty will include these workshop activities in Week 2 and 14 of the fall semester and meet during October to discuss results. Further, these workshop materials will be recommended to be included in WRI 116 / 119 portfolios with opportunity for student reflection on improvements. This diagnostic involves 8 course sections or 160 students.

Two rubrics developed from this process; we piloted the scientific literacy rubric (See ScientificLiteracyRubric.pdf) and developed a WRI 116 portfolio rubric.

Portfolio Rubric: During November 2009, WRI 116 faculty reviewed a sample of High-Middle-Low portfolio samples to discuss the iterative process of writing. For any new WRI 116 instructors this will be a means for understanding the scope of the course materials, while for returning faculty this will be an opportunity to calibrate grading and discuss standards.

Diagnostic Activity & Rubric: The rubric developed during spring 2009, from a mid-semester embedded assignment about Watson & Crick, was discussed among WRI 116 and 119 instructors during September 2009 when a pre-diagnostic was administered (See Sagan.rtf in

"Diagnostic Activity&Correspondence" folder). A post-diagnostic was administered during December 2009 (See Thomas.rtf in "DiagnosticActivity&Correspondence" folder). The scientific literacy rubric was shared with students following the diagnostics to discuss expectations about how scientific communication is supported by WRI 116 curriculum and shaped by their disciplinary fields.

From the pre and post review process, we learned that students enter into WRI 116 believing that scientific communication tends to be objective, lacking narrative elements like metaphor or personal references such as "I" or self-reflection. Although all students could identify how scientific inquiry is defined in the opening paragraph, their ability to distinguish between scientific and non-scientific language in the remaining part of the text showed disparate responses. Students lacked agreement about how to define scientific and non-scientific writing, as shown by the summary table for September's results. These results do not necessarily reflect a lack of scientific understanding; rather, consensus needs to be established about how to identify the features of scientific communication.

The post-exams (December) indicate a more nuanced understanding of scientific communication, including a richer and more accurate description of the scientific method as well as a wider awareness of audience expectations. For example, responses to the text in Question 1 go beyond the opening paragraph, identifying more complex explanations for how to define scientific communication. It is also notable that the summary table for December reflects a greater level of agreement about scientific communication elements.

*Although all sections participated in the diagnostic, faculty did not return student work within specified timeframes. Should this study be conducted again, it should be done electronically. To summarize, the N is about 25 for these comparisons. All WRI 116 and 119 faculty met to discuss these results (8 faculty, student N of 160); the student work represented in this summary matched those discussed results. For more details about results, see attached WRI116DiagnosticSummary.pdf).

Results of Review: This assessment process offered faculty opportunity to calibrate grading practices and refine benchmarks for student success. In particular, we reviewed scientific literacy in its broader societal terms, based on the above two UCM general education guiding principles.

The pre-test and portfolio review provided formative assessment opportunities, with which faculty can base curriculum refinement or new classroom activities.

Course of Action (by December 2009): Results from the pilot effort to implement upper-division writing diagnostics will inform its broader implementation. Scientific literacy rubric has been applied to workshop activities.

Summary Chart

***** Please note that process will be completed by December 2009 for reporting purposes

Date	Review Process	Results of Review
Spring 2009	(Core 1) Collect H-M-L samples of cumulative essay (Core 100) Collect and review aligned assignment H-M-L results	(Core 100) Draft rubric
Summer 2009	(Core 1) Review H-M-L samples (Core 100) Discuss potential text for diagnostics	(Core 1) Draft rubric (Core 100) Draft four diagnostics
Fall 2009	(Core 1) Review H-M-L samples with self-assessment narrative (Core 100/WRI 116) Review H-M-L portfolio samples (Core 100) Review diagnostic results	(Core 1) Refined rubric, grading calibration (Core 100) Refined rubric, grading calibration, evaluation of diagnostic pilot

Course of Action Summary (Spring 2010)

(All Sections) Discuss results in FIGs, post summary report on WP site of CROPS
(Core 1) Implement self-assessment cover letter and apply rubric
(Core 100) Implement diagnostic beyond pilot effort and apply rubric

Writing Program
Scientific Literacy within Self & Society
WRI 116: Writing in the Sciences
December 2009

SUMMARY:

From the pre and post review process, we learned that students enter into WRI 116 believing that scientific communication tends to be objective, lacking narrative elements like metaphor or personal references such as "I" or self-reflection. Although all students could identify how scientific inquiry is defined in the opening paragraph, their ability to distinguish between scientific and non-scientific language in the remaining part of the text showed disparate responses. Students lacked agreement about how to define scientific and non-scientific writing, as shown by the summary table for September's results. These results do not necessarily reflect a lack of scientific understanding; rather, consensus needs to be established about how to identify the features of scientific communication.

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RESULTS [September 2009]
Pre-Test, Lewis Thomas selection

1. **According to the article how is science defined? (Two proposed definitions)**
[n=15] Paragraph 1: "Science gets most of its information by the process of reductionism, exploring the details then the details, until all the smallest parts of the mechanism, are laid out for counting and scrutiny"
[n=7] Paragraph 2: "Science is the apprehension that we may forever be overlooking the whole by an endless, obsessive preoccupation with parts."

2. **Thomas's definition relative to others:** "Most people, or scientists more specifically, feel the reductionist part of science is crucial to understanding the whole. Other people, however, feel we must focus more on the whole, as ecology does for example. Because we live in 'the whole' so to speak, we should be able to study it in its entirety, without having to break it apart."

3. **In which part of the essay is Thomas most scientific in his method of thought and discussion?**

Paragraph	Frequency	Quotes
1	**2**	scientific level of diction
2	**1**	"objective description throughout"
3	**6**	"science is not close-ended," "anatomy and physiology mentioned"
4	**4**	
5	**9**	"refers to specific scientific processes," "includes scientific data and vocabulary"
6	**2**	"science is about understanding behavior and development"
7	**0**	
8	**5**	"scientific terms and vocabulary"
9	**1**	

4. **Where does he seem least scientific?**

Paragraph	Frequency	Quotes
1	**0**	
2	**5**	"just describes scenery"
3	**3**	"focuses on personal feelings"
4	**1**	"talks about himself which isn't scientific at all"
5	**2**	"self-learning is not scientific; it is subjective and one-sided, without facts," "jumps to conclusions"
6	**2**	"careless and personal here"
7	**5**	"does not include scientific vocabulary here," "words like 'weakness' or 'sin' seem more like a philosopher or poet than scientist"
8	**1**	
9	**4**	"discusses experience through emotions, which by rule tends to not be scientific," "altruism appeals to emotions rather than being scientific"

Compilation

Paragraph	Frequency (Most Scientific)	Frequency (Least Scientific)
1	2	0
2	1	5
3	6	3
4	4	1
5	9	2
6	2	2
7	0	5
8	5	1
9	1	4

SUMMARY OF RESULTS [DECEMBER 2009]

1. **According to the article how is science defined? (Two proposed definitions)** Data summary – In some cases students provided only 1 definition. Some definitions are banked within the same paragraph.

(A)Para 1 "Science is a way of thinking much more than it is a body of knowledge." [12]
(B) "Science is based on experiment, on a willingness to challenge old dogma, on an openness to see the universe as it really is." [12]
(C)Para 2: [1]
(D) Para. 10 [9]

2. **Sagan's definition relative to others.**

(A) Many people, including myself, believe that science is conducting experiments, looking through microscopes, and discovering things at the cell level. However, Sagan's definition about science makes us think more in depth. Rather than solving one question, you solve many questions. The methods of science are based on a hypothesis (etc.), where you have one question to test for/against. Sagan wants you think of more than one question because in order to gain full understanding for one topic, you have to look at the whole picture and ask many questions.

(B) The prevailing view of science is that simply employing experiments, and critically examining the universe is enough to qualify an action as science, whereas Sagan's philosophy further requires that there be a purpose behind the activity.

(C) The idealistic view of science is often built from skepticism, continuously doubting all of our experiences and only relying on our inner intuitions. Carl Sagan's view of science falls much more under the wildly different and completely opposite empirical range of thought, that science is how humans interpret and use experience to pose further questions about their surroundings.

3. **In which part of the essay is Sagan most scientific in his method of thought and discussion?**

Paragraph	Frequency	Quotes
1	**1**	
2	**0**	
3	**1**	
4	**0**	
5	**5**	"Sagan used the information to compare and contrast to make a point and then stated his conclusion from it"
6	**5**	"his ability to explain the anatomy and physiology of the brain so simply made his writing seem scientific"
7	**1**	
8	**3**	
9	**0**	
10	**0**	
11	**0**	
12	**1**	

13	**5**	number of possible things we must understand about the crystal before we "know" it
14	**0**	
15	**0**	

4. **Where does he seem least scientific?**

Paragraph	Frequency	Quotes
1	**0**	
2	**2**	
3	**4**	"Although he does asks scientific questions such as 'Why are the Sun and the moon and the planets spheres?' he doesn't necessarily answers the questions with scientific explanations"
4	**2**	
5	**2**	
6	**1**	
7	**0**	
8	**0**	
9	**0**	
10	**1**	
11	**0**	
12	**0**	
13	**0**	
14	**5**	"Sagan is questioning a lot, but he isn't really doing anything to find out the answer to his questions"
15	**5**	"Science cannot be based on opinion or own conclusions"

Compilation

Paragraph	Frequency (Most Scientific)	Frequency (Least Scientific)
1	**1**	**0**
2	**0**	**2**
3	**1**	**4**
4	**0**	**2**
5	**5**	**2**
6	**5**	**1**
7	**1**	**0**
8	**3**	**0**
9	**0**	**0**
10	**0**	**0**
11	**0**	**0**
12	**1**	**0**
13	**5**	**0**
14	**0**	**5**
15	**0**	**5**

Anne Zanzucchi <anne.zanzucchi@gmail.com>

WRI 116 (&119), diagnostic

2 messages

Anne Zanzucchi <azanzucchi@ucmerced.edu> **Thu, Aug 6, 2009 at 3:48 PM**

To: Paul Gibbons <pgibbons@ucmerced.edu>, skahlert <skahlert@ucmerced.edu>, "Mary S. Smith" <msmith5@ucmerced.edu>, Mary Soltis <msoltis@ucmerced.edu>, nvaldez@ucmerced.edu, "Elizabeth Olson (eolson@ucmerced.edu)" <eolson@ucmerced.edu>, "Nuno Sena (nsena2@ucmerced.edu)" <nsena2@ucmerced.edu>, Thomas Hothem <tehothem@gmail.com>, Jeremy Mumford <jmumford@ucmerced.edu>, Jeremy Mumford <mumford.j@mccd.edu>, Shirley Kahlert <stoneleigh@clearwire.net>, Mary Smith <tesolmary@gmail.com>, Robert Ochsner <rochsner@ucmerced.edu>

Hello all,

Hope you are doing well; I am writing with a brief update about WRI 116/119 diagnostic work and a request for your input. First, please find attached the Writing Program's assessment schedule for next year, written to summarize standard practices within our program and to highlight new ones related to accreditation. Related to WRI 116/119 instruction is an activity that was recommended by previous WRI 116/119 faculty -- a brief pre/post diagnostic of reading and analysis skills (focused around scientific literacy) for upper-division writing courses. Please read the schedule, particularly the top of page 2 for the basic summary of how we are planning to conduct the diagnostic.

Also attached are two brief texts related to science, in whichever order as pre and post diagnostic makes sense given the context of your reading schedule. The blue font are the suggested "answers" or anticipated responses to the question. During Weeks 2 and 14, students should have about 30 minutes to read the text and respond to questions. In addition to our primary focus on evaluating student responses and gaining a broad perspective on their reading and analysis skills, I am hoping that if desired these selected texts can be easily adapted into a discussion or activity (not necessary, of course).

As mentioned in the assessment summary, we will meet in October to review sample responses to these prompts. For those of you are who new to WRI 116, we generally meet once a month to discuss issues and exchange ideas, so this would be during a routine meeting time.

Your feedback on this diagnostic activity would be much appreciated. If you would like any questions added or modified, please advise. A final copy of materials will be posted on CROPS and circulated to our group a few days before the WP orientation (scheduled for the morning of Friday, August 21 -- soon to be announced). In the interim, if you have any questions at all please feel free to be in touch with me or our group.

All the best,

Anne.

3 attachments

UpperDivisionText.pdf
407K

GE&WP_AssessmentSchedule[2].doc
37K

UpperDivisionQuestions.doc
30K

Mail Delivery Subsystem <MAILER-DAEMON@luigi.ucmerced.edu> **Thu, Aug 6, 2009 at 3:48 PM**
To: anne.zanzucchi@gmail.com

The original message was received at Thu, 6 Aug 2009 15:48:53 -0700 (PDT)
from mail-qy0-f193.google.com [209.85.221.193]

----- The following addresses had permanent fatal errors -----
<jmumford@ucmerced.edu>
(reason: 550 <jmumford@ucmerced.edu>: Recipient address rejected: User unknown in relay recipient table)

----- Transcript of session follows -----
... while talking to [169.236.253.67]:
>>> DATA
<<< 550 <jmumford@ucmerced.edu>: Recipient address rejected: User unknown in relay recipient table
550 5.1.1 <jmumford@ucmerced.edu>... User unknown

Final-Recipient: RFC822; jmumford@ucmerced.edu
Action: failed
Status: 5.1.1
Remote-MTA: DNS; [169.236.253.67]
Diagnostic-Code: SMTP; 550 <jmumford@ucmerced.edu>: Recipient address rejected: User unknown in relay recipient table
Last-Attempt-Date: Thu, 6 Aug 2009 15:48:57 -0700 (PDT)

---------- Forwarded message ----------
From: Anne Zanzucchi <azanzucchi@ucmerced.edu>
To: Paul Gibbons <pgibbons@ucmerced.edu>, skahlert <skahlert@ucmerced.edu>, "Mary S. Smith" <msmith5@ucmerced.edu>, Mary Soltis <msoltis@ucmerced.edu>, nvaldez@ucmerced.edu, "Elizabeth Olson (eolson@ucmerced.edu)" <eolson@ucmerced.edu>, "Nuno Sena (nsena2@ucmerced.edu)" <nsena2@ucmerced.edu>, Thomas Hothem <tehothem@gmail.com>, Jeremy Mumford <jmumford@ucmerced.edu>, Jeremy Mumford <mumford.j@mccd.edu>, Shirley Kahlert <stoneleigh@clearwire.net>, Mary Smith <tesolmary@gmail.com>, Robert Ochsner <rochsner@ucmerced.edu>
Date: Thu, 6 Aug 2009 15:48:40 -0700
Subject: WRI 116 (&119), diagnostic
Hello all,

Hope you are doing well; I am writing with a brief update about WRI 116/119 diagnostic work and a request for your input. First, please find attached the Writing Program's assessment schedule for next year, written to summarize standard practices within our program and to highlight new ones related to accreditation. Related to WRI 116/119 instruction is an activity that was recommended by previous WRI 116/119 faculty -- a brief pre/post diagnostic of reading and analysis skills (focused around scientific literacy) for upper-division writing courses. Please read the schedule, particularly the top of page 2 for the basic summary of how we are planning to conduct the diagnostic.

<azanzucchi@ucmerced.edu>
wrote:
[Quoted text hidden]

Anne Zanzucchi <azanzucchi@ucmerced.edu> **Mon, Oct 5, 2009 at 11:54 AM**
To: Paul Gibbons <pgibbons@ucmerced.edu>, skahlert <skahlert@ucmerced.edu>, "Mary S. Smith" <msmith5@ucmerced.edu>, nvaldez@ucmerced.edu, "Elizabeth Olson (eolson@ucmerced.edu)" <eolson@ucmerced.edu>

Hello all,

This is a friendly reminder that we are meeting tomorrow at 11:30 in the White Oak Room to discuss WRI 116.

We will be discussing the results of the diagnostic. Gold star to everyone for getting this done and frowny face to Anne for a convoluted step! With everything Linda has to juggle with other diagnostics, it would have been simpler to have the packets delivered to my office. The two other Lewis Thomas diagnostic packets are currently lost in the shuffle. If they are unearthed, I will add to the attached results summary (only of Paul's class currently). The other is a summary of the Sagan results from Mary's class. Despite the limited sample size, we will focus on discussing these results. There are several key points we can extrapolate from this data about student assumptions about science writing that are worth discussing.

In November, we will be discussing three portfolio samples. I will email you the portfolio links in separate correspondence following our meeting tomorrow. Our purpose will be to rate them as high-middle-low and to discuss survey questions related to better defining what we mean by successfully achieving the "iterative process of writing" (our annual Program Learning Outcome).

Please find attached a chapter from Scott Warnock's Teaching Writing Online, which might be of interest given our prior conversation about online discussion groups. In December we will want to determine some online projects with WRI 116 to pilot moving some sections to a hybrid format (only a few days, nothing intensive). To prepare for these discussions, this may be a starting point for brainstorming some ideas.

So our meeting tomorrow will focus on the current diagnostic results with respect to the general education learning outcome: "recognizing the role scientists play in educating the public" we determined as a focus in the Sept. meeting. There will also be opportunity to discuss classroom dynamics and issues.

See you soon!

Anne.
[Quoted text hidden]

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3 attachments

Warnock.pdf
1070K

Can We Know the Universe?

Reflections on a Grain of Salt

Nothing is rich but the inexhaustible wealth of nature.
She shows us only surfaces, but she is a million fathoms deep.
Ralph Waldo Emerson

[1] Science is a way of thinking much more than it is a body of knowledge. Its goal is to find out how the world works to seek what regularities there may be, to penetrate to the connections of things – from subnuclear particles, which may be the constituents of all matter, to living organisms, the human social community, and then to the cosmos as a whole. Our intuition is by no means an infallible guide. Our perception may be distorted by training and prejudice or merely because of the limitations of our sense organs, which, of course, perceive directly but a small fraction of the phenomena of the world. Even so straightforward a question as whether in the absence of friction a pound of lead falls faster than a gram of fluff was answered incorrectly by Aristotle and almost everyone else before the time of Galileo. Science is based on experiment, on a willingness to challenge old dogma, on an openness to see the universe as it really is. Accordingly, science sometimes requires courage – at the very least the courage to question the conventional wisdom.

[2] Beyond this the main trick of science is to *really* think of something the shape of clouds and their occasional sharp bottom edges at the same altitude everywhere in the sky; the formation of a dewdrop on a leaf; the origin of a name or a word – Shakespeare, say, or "philanthropic"; the reason for human social customs – the incest taboo, for example; how it is that a lens in sunlight makes paper burn; how a "walking stick" got to look so much like a twig; why the Moon seems to follow us as we walk; what prevents us from digging a hole down to the center of the Earth; what the definition is of "down" on a spherical Earth; how it is possible for the body to convert yesterday's lunch into today's muscle and sinew; or how far is up – does the universe go on forever, or if it does not, is there any meaning to the question of what lies on the other side? Some of these questions are pretty easy. Others, especially the last, are mysteries to which no one even today knows the answer. They are natural questions to ask. Every culture has posed such questions in one way or another. Almost always the proposed answers are in the nature of "Just So Stories," attempted explanations divorced from experiment, or even from careful comparative observations.

[3] But the scientific cast of mind examines the world critically as if many alternative worlds might exist, as if other things might be here which as not. Then we are forced to ask why what we see is present and not something else. Why are the Sun and the Moon and the planets spheres? Why not pyramids, or cubes, or dodecahedra? Why not irregular, jumbly shapes? Why so symmetrical, worlds? If you spend any time spinning hypothesis, checking to see whether they make sense, whether they conform to what else we know, thinking of tests you can pose to substantiate or deflate your hypothesis, you will find yourself doing science. And as you come to practice this habit of thought more and more you will get better and better at it. To penetrate into the heart of the thing – even a little thing, a blade of grass, as Walt Whitman said – is to experience a kind of exhilaration that, it may be,

only human beings of all the beings on this planet can feel. We are an intelligent species and the use of our intelligence quite properly gives us pleasure. In this respect the brain is like a muscle. When we think well, we feel good. Understanding is a kind of ecstasy.

[4] But to what extent can we *really* know the universe around us? Sometimes this question is posed by people who hope the answer will be in the negative, who are fearful of a universe in which everything might one day be known. And sometimes we hear pronouncements from scientists who confidently state that everything worth knowing will soon be known – or even is already known – and who paint pictures of a Dionysian or Polynesian age in which is zest for intellectual discovery has withered, to be replaces by a kind of subdued languor, the lotus eaters drinking fermented coconut milk or some other mild hallucinogen. In addition to maligning both the Polynesians, who were intrepid explorers (and whose brief respite in paradise is now sadly ending), as well as the inducements to intellectual discovery provided by some hallucinogens, this contention turns out to be trivially mistaken.

[5] Let us approach a much more modest question: not whether we can know the universe of the Milky Way Universe or a star or a world. Can we know, ultimately and in detail, a grain of salt? Consider one microgram of table salt, a speck just barely large enough for someone with keen eyesight to make out without a microscope. In that grain of salt there are about 10^{16} sodium and chloride atoms. This is a 1 followed by 16 zeroes, 10 million billion atoms. If we wish to know a grain of salt, we must know at least the three-dimensional positions of each of these atoms. (In fact, there is much more to be known – for example, the nature of the forces between the atoms – but we are making only a modest calculation.) Now, is this number more or less than the number of things which the brain can know?

[6] How much *can* the brain know? There are perhaps 10^{11} neurons in the brain, the circuit elements and switches that are responsible in their electrical and chemical activity for the functioning of our minds. A typical brain neuron has perhaps thousands of little wires, called dendrites, which connect it with its fellows. If, as seems likely, every bit of information in the brain corresponds to one of these connections, the total number of things knowable by the brain is no more than 10^{14}, one hundred trillion. But this number is only one percent of the number of atoms in our speck of salt.

[7] So in this sense the universe is intractable, astonishingly immune to any human attempt at full knowledge. We cannot on this level understand a grain of salt, much less the universe.

[8] But let us look more deeply at our microgram of salt. Salt happens to be a crystal in which, except for defects in the structure of the crystal lattice, the position of every sodium and chlorine atom is predetermined. If we could shrink ourselves into this crystalline world, we could see rank upon rank of atoms in an ordered array, a regularly alternating structure – sodium, chlorine, sodium, chlorine, specifying the sheet of atoms we are standing on and all the sheets above us and below us. An absolutely pure crystal salt could have the position of every atom specified by something like 10 bits of information. [1] This would not strain the information carrying capacity of the brain.

[9] If the universe had natural laws that governed its behavior to the same degree of regularity that determines a crystal of salt, then, of course, the universe would be knowledgeable. Even if there were many such laws, each of considerable complexity, human beings might have the capacity to understand

them all. Even if such knowledge exceeded the information-carrying capacity of the brain, we might store the additional information outside our bodies – in books, for example, or in computer memories – and still, in some sense, know the universe.

[10] Human beings are, understandably, highly motivated to find regularities, natural laws. The search for rules, the only possible way to understand such a vast and complex universe, is called science. The universe forces those who live in it to understand. Those creatures who find everyday experience a muddled jumble of events with no predictability, no regularity, are in grave peril. The universe belongs to those who, at least to some degree, have figured it out.

[11] It is an astonishing fact that there *are* laws of nature, rules that summarize conveniently – not just qualitatively by quantitatively – how the world works. We might imagine a universe in which there are no such laws, in which the 10^{80} elementary particles that make up a universe like our own behave with utter and uncompromising abandon. To understand such a universe we would need a brain at least as massive as the universe. It seems unlikely that such a universe would have life and intelligence, because beings and brains require some degree of internal stability and order. But even if in a much more random universe there were such beings with and intelligence much greater than our own, there could not be much knowledge, passion or joy.

[12] Fortunately for us, we live in a universe that has at least important parts that are knowable. Our common-sense experience and out evolutionary history have prepared us to understand something of the workaday world. When we go into other realms, however, common sense and ordinary intuition turn out to be highly unreliable guides. It is stunning that as we go close to the speed of light our mass increases indefinitely, we shrink toward zero thickness in the direction of motion, and time for us comes as near to stopping as we would like. Many people think that this is silly, and every week or two I get a letter from someone who complains to me about it. But it is a virtually certain consequence not just of experiment but also of Albert Einstein's brilliant analysis of space and time called the Special Theory of Relativity. It does not matter that these effects seem unreasonable to us. We are not in the habit of traveling close to the speed of light. The testimony of our common sense is suspect to high velocities.

[13] Or consider an isolated molecule composed of two atoms shaped something like a dumbbell – a molecule of salt, it might be. Such a molecule rotates about an axis through the line connecting two atoms. But in the world of quantum mechanics, the realm of the very small, not all orientations of our dumbbell molecule are possible. It might be that molecule could be oriented in a horizontal position, say, or in a vertical position, but not at many angles in between. Some rotational positions are forbidden. Forbidden by what? By the laws of nature. The universe is built in such a way as to limit, or quantize, rotation. We do not experience this directly in everyday life; we would find it startling as well as awkward in sitting-up exercises, to find arms outstretched from the sides or pointed up to the skies permitted but many intermediate positions forbidden. We do not live in the world of the small, on the scale of 10^{-13} centimeters, in the realm where there are twelve zeroes between the decimal place and the one. Our common-sense intuitions do not count. What does count is experiment – in this case, observations of the infrared spectra of molecules. They show molecular rotation to be quantized.

[14] The idea that the world restrictions on what humans might do is frustrating. Why *shouldn't* we be able to have intermediate rotational positions? Why *can't* we travel any faster than the speed of light? But so far as we can tell, this is the way the universe is constructed. Such prohibitions not only press us toward a little humility; they also make the world more knowable. Every restriction corresponds to a law of nature, a regularization of the universe. The more restrictions there are on what matter and energy can do, the more knowledge human beings can attain. Whether in some sense the universe is ultimately knowable depends not only on how many natural laws there are that encompass widely divergent phenomena, but also on whether we have the openness and the intellectual capacity to understand such laws. Our formulations of the regularities of nature are surely dependent on how the brain is built, but also, and to a significant degree, on how the universe is built.

[15] For myself, I like a universe that includes much that is unknown and, at the same time, much that is knowable. A universe in which everything is known would be static and dull, as boring as the heaven of some weak-minded theologians. A universe that is unknowable is no fit place for a thinking being. The ideal universe for us is one very much like the universe we inhabit. And I would guess that this is not really much of a coincidence.

Exam B Diagnostic

Name: _____

(1) According to the article, how is science defined? What are the proposed definitions? (please quote directly from text)

(2) What is Sagan's definition relative to other ways of thinking about science?

(3) In which part of the essay (or which paragraphs) does Sagan seem to be most scientific in his method of thought and discussion? How so?

(4) Where does he seem least scientific? How so?

The Tucson Zoo

Lewis Thomas

[1] Science gets most of its information by the process of reductionism, exploring the details, then the details, until all the smallest parts of the mechanism, are laid out for counting and scrutiny. Only when this is done can the investigation be extended to encompass the whole organism or the entire system. So we say.

[2] Sometimes it seems that we take a loss, working this way. Much of today's public anxiety about science is the apprehension that we may forever be overlooking the whole by an endless, obsessive preoccupation with the parts. I had a brief, personal experience of this misgiving one afternoon in Tucson, where I had time on my hands and visited the zoo, just outside the city. The designers there have cut a deep path-way between two small artificial ponds, walled by clear glass, so when you stand in the center of the path you can look into the depths of each pool, and at the same time you can regard the surface. In one pool, on the right side of the path, is a family of otters; on the other side, a family of beavers. Within just a few feet from your face, on either side, beavers and otters are at play, underwater and on the surface, swimming toward your face and then away, more filled with life than any creatures I have ever seen before, in all my days. Except for the glass, you could reach across and touch them.

[3] I was transfixed. As I know recall is, there was only one sensation in my head: pure elation mixed with amazement at such perfection. Swept off my feet, I floated from one side to the other, swiveling my brain, staring astounded at the beavers, then at the otters. I could hear shouts across my corpus callosum, from one hemisphere to the other. I remember thinking, with what was left in charge of my consciousness, that I wanted no part of the science of beavers and otters; I wanted never to know how they performed their marvels; I wished for no news about the physiology of their systems, their digestive tracts. I hoped never to have to think of them as collections of cells. All I asked for was the full hairy complexity, then in front of my eyes, of whole, intact beavers and otters in motion.

[4] It lasted, I regret to say, for only a few minutes, and then I was back in the late twentieth century, reductionist as ever, wondering about the details by force of habit, but not, this time, the details of otters and beavers. Instead, me. Something worth remembering had happened in my mind, I was certain of that; I would have put it somewhere in the brain stem; maybe this was my limbic system at work. I became a behavioral scientist, an experimental psychologist, an ethologist, and in the instant I lost all the wonder and the sense of being overwhelmed. I was flattened.

[5] But I came away from the zoo with something, a piece of news about myself: I am coded, somehow, for otters and beavers. I exhibit instinctive behavior in their presence, when they are displayed close at hand behind glass, simultaneously below water and at the surface. I have receptors for this display. Beavers and otters possess a "release" for me, in the terminology of ethology, and the releasing was my experience. What was released? Behavior. What behavior? Standing, swiveling, flabbergasted, feeling exultation and a rush of friendship. I could not, as the result of the transaction, tell you anything more about beavers and otters than you already know. I learned nothing new about

them. Only about me, and I suspect also about you, maybe about human beings at large: we are endowed with genes which code out our reaction to beavers and otters, maybe our reaction to each other as well. We are stamped and stereotyped, unalterable patterns of response, ready to be released. And the behavior released in us, by such confrontations, is, essentially, a surprised affection. It is compulsory behavior and we can avoid it only by straining with the full power of out conscious minds, making up conscious excuses all the way. Left to ourselves, mechanistic and autonomic, we hanker for friends.

[6] Everyone says, stay away from ants. They have no lessons for us; they are crazy little instruments, inhuman, incapable of controlling themselves, lacking manners, lacking souls. When they are massed together, all touching, exchanging bits of information help in their jaws like memoranda, they become a single animal. Look out for that. It is a debasement, a loss of individuality, a violation of human nature, an unnatural act.

[7] Sometimes people argue this point of view seriously and with deep thought. Be individuals, solitary and selfish, is the message. Altruism, a jargon word for what used to be called love, is worse than weakness, it is sin, a violation of nature. Be separate. Do not be a social animal. But this is a hard argument to make convincingly when you have to depend on language to make it. You have to print up leaflets or publish books and get them bought and sent around, you have to turn up on television and catch the attention of millions of other human beings all at once, and then to have to say to all of them, all at once, all collected and paying attention: be solitary; do not depend on each other. You can't do this and keep a straight face.

[8] Maybe altruism is out most primitive attribute, out of reach, beyond out control. Or perhaps it is immediately at hand, waiting to be released, disguised now, in our kind of civilization, as affection or friendship or attachment. I don't see why it should be unreasonable for all human beings to have strands of DNA coiled up in chromosomes, coding out instincts for useful for survival, more important than aggression, more effective, in the long run, than grabbiness. If this is the sort of information biological science holds for the future, applying to us as well as to ants, then I am all for science.

[9] One thing I'd like to know most of all: when those ants have made the hill, and are all there, touching and exchanging, and the whole mass beings to behave like a single huge creature, and *thinks*, what on earth is that thought? And while you're at it, I'd like to know a second thing: when it happens, does any single ant know about it? Does his hair stand on end?

Diagnostic A Questions

Name: _____

(1) According to the article, how is science defined? Please identify at least two proposed definitions and quote directly from the text as support.

(2) What is Thomas's definition relative to other ways of thinking about science?

(3) In which part of the essay (or which paragraphs) does Thomas seem to be most scientific in his method of thought and discussion? How so?

(4) Where does he seem least scientific? How so?

Pre and Post Scientific Literacy Reading Diagnostics

Exam A: Lewis Thomas's "The Tucson Zoo"

(1) According to the article, how is science defined? Please identify at least two proposed definitions and quote directly from the text as support.

Para. 1 General consensus: "Science gets most of its information by the process of reductionism, exploring the details, then the details of the details, until the smallest bits of the structure, or the smallest parts of the mechanism, are laid out for counting and scrunity."

Para 2 Alternative perspective: "Much of today's public anxiety about science is the apprehension that we may forever be overlooking the whole by an endless, obsessive preoccupation with the parts."

Para 8 Thomas: "Maybe altruism is our most primitive attribute, out of reach, beyond our control. Or perhaps it is immediately at hand, waiting to be released, disguised now, in our kind of civilization, as affection or friendship or attachment. … If this is the sort of information biological science holds for the future, applying to us as well as to ants, then I am all for science."

(2) What is Thomas's definition relative to other ways of thinking about science?

Can science identify what is extrinsic or intrinsic?

(3) In which part of the essay (or which paragraphs) does Thomas seem to be most scientific in his method of thought and discussion? How so?

para 2, description of zoo is methodical, goes from large to small details

(4) Where does he seem least scientific? How so?

para. 5, open questions and lots of adjectives, emotional not objective

Exam B: Carl Sagan "Can We Know the Universe? Reflections on a Grain of Salt"

(1) According to the article, how is science defined? What are the proposed definitions? (please quote directly from text)

Para 1: "Science is a way of thinking much more than it is a body of knowledge. It's goal is to find out how the world works, to seek what regularities there may be, to penetrate to the connections of things."

Para 1: "Science is based on experiment, on a willingness to challenge old dogma, on an openness to see the universe as it really is."

Para 2: "Beyond this the main trick of science is to really think of something: the shape of clouds and their occasional sharp bottom edges at the same altitude everywhere in the sky, etc."

(2) What is Sagan's definition relative to other ways of thinking about science?

It is possible to not be able to know everything about objects or phenomena

Para 15: "I like a universe that includes much that is unknown and at the same time, much that is knowable.

(3) In which part of the essay (or which paragraphs) does Sagan seem to be most scientific in his method of thought and discussion? How so?

Para 6: Consider one microgram of table salt…

(4) Where does he seem least scientific? How so?

Para 14: The idea that the world places restrictions…

WRI 116: Writing in the Natural Sciences
Scientific Literacy Rubric
April 2009
Authors: Paul Gibbons, Nuno Sena & Anne Zanzucchi

	Interpretation	**Analysis**	**Technical Writing Skills w/in Context**	**Scientific discourse**	**Synthesis** [1]
High	correct identification of main ideas, demonstrates rich and complete understanding of original text	all claims are supported by direct or paraphrased evidence, able to explain the significance of detail and main ideas	mixture of simple and complex sentence structures, virtually error free punctuation, spelling and format	strong vocabulary with deliberate and specific word choice, reflects strong audience-awareness	
Middle	basic argument is identified though may not distinguish significant categories or topics within argument	includes supporting evidence or paraphrased detail though not for all claims, may generalize, generally interprets major argumentative patterns	occasional usage errors, repetitive syntax, contains several common punctuation, spelling and format issues	occasionally inconsistent diction and tone, includes some professional vocabulary but may lack precision	
Low	may misunderstand basic claims in text or attends to ancillary details rather than main guiding ideas	evidence is not embedded in interpretation, lacks full perspective on implications, tends to generalize	minimal sentence variety, non-specific verbs, frequent grammatical errors that impede meaning	inappropriate diction, weak command of professional vocabulary. inaccurate uses of passive or active voice	

[1] Watson Crick workshop assignment does not include a synthesis step. In Fall 2009, WRI 116 instructors will evaluate literature reviews to develop synthesis criteria.