The Engage Program

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Contents

The Engage Vision

Science is critical to the advancement and safety of human society. Unfortunately, scientific knowledge and discovery has become mostly restricted to a few, highly trained specialists — graduate students and PhDs. What is perhaps more unfortunate is that these same specialists are typically without training in how to convey the importance of their work to the general public, allowing those with media training and, sometimes, ulterior motives to discuss the significance of scientific findings.

Scientists are trained to investigate, report, and interpret facts and data. What we often fail to understand is that this ability is the result of years of instruction in how to approach science — a training that most non-scientists have never received. Scientific information, when presented as a dry collection of facts and figures, often fails to capture the appropriate attention or conjure the impact it deserves. In order to reach a broad and, at times, uninterested audience, scientists must learn to convey important information in an engaging and accessible way.

The Engage Program teaches emerging scientists how to be effective communicators, incorporating lessons and tools from a variety of sources: improvisational games, group discussion and feedback, and, most importantly, practice. By enabling students to learn a set of skills and techniques for communication, we ensure that the importance and thrill of scientific discovery is understandable to everyone, layman and specialist alike.

Document Summary

The purpose of this document is to provide the materials needed for an institution (or individual) to form their own branch of the Engage Program — training students to be effective science communicators and enabling the students to bring their message to the public. This is a two-step process, involving, first, a course that teaches the students about science communication, and, second, a public lecture series featuring the Engage students.

Most of the content of this document is dedicated to the materials that one would need to teach a science communication course. These are divided into three categories: in-class lessons (i.e., lecture and discussion topics), in-class activities, and assignments. We also provide an example course schedule and syllabus. Once you have decided on a schedule for your own course, you can pick and choose from the relevant materials, activities, and assignments to tailor the course to your own preferences. While not explicitly stated in some places, most of the activities and assignments work best when followed by class discussions.

A great deal of the course content is aimed at getting the students to assemble a public talk on their own research. This presentation is an integral part of the Engage curriculum, as it puts theory into practice, providing the students a chance to discuss their work with the public. To that end, the final chapter of this document contains a summary of some of the wisdom that we have accumulated while teaching the Engage course and assembling various public lecture series. Our intention is to make the implementation of the Engage Program as straightforward as possible.

In-Class Lessons

Presented here is a set of lessons for use in preparing your own Engage-like course. We include an example course schedule and syllabus, as well as a variety of materials in the form of lecture and discussion topics.

3.1 Example Schedule

At the University of Washington, the Engage course is taught with about 30 hours of time spent in the classroom, meeting once every week over a 10-week quarter. This amount of class time could be easily grown or shrunk depending on the number of students and the amount of time spent on in-class discussions. We also recommend that every class begins with an improv activity (see Section 4.2). The table below presents a typical course schedule, a provides references to the various sections of this document which are relevant to specific topics.

Week	Topic(s)	Relevant Section(s)
1	Introductions; Improv; Storytelling	3.3; 4.1; 4.2; 5.1
2	Extended Improv; Jargon	3.4; 4.2; 4.3; 5.2
3	Storyboarding	3.5; 4.4; 5.3
4	Audience Considerations	4.5; 5.4
5	Choosing Content; Cocktail Party	4.6; 4.7; 5.5
6	Distilling vs. Dumbing Down; Analogies	3.6; 4.8; 5.6
7	Public Speaking	3.7; 4.9
8	Practice Talks	4.10
9	Practice Talks	4.10
10	Practice Talks	4.10

When teaching our course, we often benefit from inviting guest speakers to the class. These may be students or faculty trained in a relevant field (e.g., visual design), or these guests may be people from outside the university (e.g., employees from a local science or natural history museum). Please consider reaching out to similar members of your community when assembling your Engage-like course — you'll be surprised at how much support is out there.

Finally, while not discussed in the materials presented here, a longer course on science communication could benefit from including content on written communication skills (i.e., writing for non-scientists), giving scientific interviews, and the use of social media. To develop this content, try reaching out to science writers in your area as well as science-publicists (which many universities employ).

3.2 Example Syllabus

Communicating Science to the Public Effectively

Instructor: [name]
[class time] in [room]
[course website]

~

[name]; email: [email address]

~

"We have [...] arranged things so that almost no one understands science and technology. This is a prescription for disaster. We might get away with it for a while, but sooner or later this combustible mixture of ignorance and power is going to blow up in our faces." - Carl Sagan

~

Course Description:

This course focuses on developing effective techniques for sharing scientific research with non-specialists. We will focus on development of sound-bytes, elevator talks, accessible visualizations and story telling. Students will spend time exploring their voice, crafting their message and telling their story through improvisation and group discussion. The product of this course will be a 30-minute, engaging public presentation.

Course Goals:

In this course, students will:

- develop and practice several analogies to distill their research.
- create a variety of concise statements that describe their research.
- practice story-telling and ways of connecting with the public.
- learn improvisation, acting games and lessons.
- engage in weekly readings and discussions.
- hear from guest speakers on science communication.
- develop a 30-minute public presentation about their research.

Introduction:

"It would be possible to describe everything scientifically, but it would make no sense; it would be without meaning, as if you described a Beethoven symphony as a variation of wave pressure." - Albert Einstein

Science is critical to the advancement and safety of human society. Unfortunately, scientific knowledge and discovery has become mostly restricted to a few, highly trained specialists: graduate students and PhDs. What is perhaps more unfortunate is that these same specialists are typically without training in how to convey the importance of their work to the general public, allowing those with media training and, sometimes, ulterior motives to discuss the significance of scientific findings.

Scientists are trained to investigate, report, and interpret facts and data. What we often fail to understand is that this ability is the result of years of training in how to approach science — a training that most non-scientists have never received. Scientific information, when presented as a dry collection of facts and figures, often fails to capture the appropriate attention or conjure the impact it deserves. In order to reach a broad and, at times, uninterested audience, scientists must learn to convey important information in an engaging and accessible way. This course, through lectures by guest speakers, improvisational games, group discussion and feedback, and, most importantly, practice, will help emerging scientists prepare a set of skills and techniques for public communication.

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<u>Assignments and Grading</u>:

This course builds towards a 30-minute talk about science research for a general audience. To get there, we will practice many elements of good communication and will work hard at structuring the talk. Attendance and participation are critical components of the skills taught in this class.

20% - short written assignments, some based on readings
20% - participation in class activities (improvisation, discussions, stories, etc.)
60% - final talk (judged by quality and effort)

<u>Sources</u>:

Dean, Cornelia. *Am I Making Myself Clear? A Scientist's Guide to Talking to the Public.* Harvard University Press, 2009.

Hayes, Richard and Daniel Grossman. *A Scientist's Guide to Talking with the Media: Practical Advice from the Union of Concerned Scientists*. Rutgers University Press, 2006.

Mooney, Chris and Cheryl Kirshenbaum. *Unscientific America: How Scientific Illiteracy Threatens Our Future.* Basic Books, 2009.

Olsen, Randy. *Don't Be Such a Scientist: Talking Substance in an Age of Style.* Island Press 2009.

3.3 Storytelling

The Engage course places a very strong emphasis on storytelling. Whether the student is giving a three-sentence statement on his/her research, or delivering an hour-long talk on a scientific topic, the format should always be a story. Kristin Thomas, in *Storytelling in the New Hollywood: Understanding Classical Technique*, presents an extended discussion of the story form in the first chapter of her book, which we summarize for our students.

Note that we are trained to receive information in the form of a story — we hear our first stories as children, and continue to hear stories for the rest of our lives. When you step back and think about it, it's quite amazing how much of what we see is delivered to us in the story form. Scientific talks, however, tend not to follow the format of a story. They are dry, and typically follow the standard structure of introduction/background, methods, results, discussion, and conclusions. By emphasizing how science can easily fit into the form of a story, we break the mold of the "standard" science talk, and create science presentations that are in a format that the public is primed to receive and enjoy.

A great way to start this lesson is to tell a story from your own life. For example, one of us tells a story about a snow storm in Seattle that iced over the roads, and the adventure that followed when trying to go buy groceries. Once you've told the story, ask the students to recount it back to you — they'll remember every bit. Why is this the case? Because they are primed to receive and remember stories. Write the outline of your story on the board, and see if the students can identify the main parts of your story.

Following the lesson on storytelling, summarized below, it is great to have a discussion with the students about how their work can be told as a story. Does the protagonist have to be them? No. Maybe it can be the bacterium that they study. Can they think of any potential complicating actions in their work that might hook the audience in?

- The four main parts of a story are
  - setup
  - complicating action
  - development
  - climax
- setup
  - an initial situation is established
  - the protagonist receives 1-2 goals
- complicating action
  - takes the story in a new, exciting direction
  - the protagonist must change his/her tactics to achieve the previously established goals
  - serves as a counter setup, placing the protagonist in a new situation in which he/she must cope

- development
  - the protagonist struggles towards completing his/her goals
  - incorporates elements of action, suspense, delay, humor
  - all premises regarding goals and lines of action are introduced
- climax
  - shift from progress to resolution
  - key question: will the protagonist's goals be achieved?
- other key ideas
  - the setup should not take too long — the complicating action is what hooks the audience
  - stories can be more complicated than a straightforward application of setup, complicating action, development, and climax (although this application works well for a short presentation)
    - e.g., stories can have multiple complicating actions, with development occurring between these
- an example — *Avatar*
  - setup
    - introduce world of Pandora (Earth-like, poisonous atmosphere, mining colony)
    - meet the cast of characters (the Na'vi, Jake, Dr. Augustine)
    - introduce the avatar control system
    - goal: Jake must use the Avatar system to help study the world of Pandora
  - complicating action
    - Jake's avatar is attacked while exploring Pandora
    - Jake's avatar is saved by Neytiri, a Na'vi, and brought to Hometree
    - new direction: Jake asked to study the Na'vi "from the inside" (by both Dr. Augustine and Colonel Quaritch, who has evil intentions)
  - development
    - Jake learns about/from the Na'vi
    - a romance begins between Jake's avatar and Neytiri
  - complicating action
    - Jake switches allegiance, wants to help Na'vi fight against Col. Quaritch
  - development
    - Jake "discovered" as a spy by Na'vi
    - Hometree destroyed
    - Jake and colleagues escape to an outpost
    - Jake "captures" and rides the mythical Toruk, regaining the Na'vi's trust
  - climax
    - Na'vi, with Jake's help, defeat the humans
    - Jake permanently enters his avatar body

3.4 Jargon

The topic of "jargon" can be handled by pairing a presentation with class discussion. The central ideas are given below, and the presentation/discussion can be paired with the materials in Section 4.3.

- Why do we use jargon when speaking to our colleagues?
  - jargon can be an efficient means of communication
  - certain jargon terms have very specific definitions, which makes using these terms easier than repeating the definition
  - by using the language of your peers, you prove you are part of the "in" crowd
  - out of habit
- Why do we use jargon when speaking to the public?
  - intimidation
  - to "prove" that we are smarter than others, or better educated
- Is it necessarily bad to use jargon? No.
  - it *is* useful when speaking to your peers
  - when carefully defined and used, jargon can be utilized in a public talk to help make the discussion more efficient
  - teaching the public a jargon term can make them feel like they've learned something new, or joined the "in" crowd
- Some practical tips for avoiding jargon
  - never use equations
    - equations are "jargon within jargon" since the symbols often represent jargon terms
    - replace all equations with a discussion of the meaningful physical relation that the equation states
  - plots can lead to the use of jargon
    - axis labels are frequently jargon terms
    - try to replace a plot with a cartoon version that is easier for the public to understand, but which contains the same information
  - units and scales can be jargon terms
    - convert these into terms or numbers that are more meaningful to the public (e.g., the Sun is 1.5×10^8 km from Earth vs. it would take you almost 200 years driving in your family sedan, at 60 mi/hr, to make a trip from Earth to the Sun)

- complicated concepts can be translated (by analogy) to something that is easier for the audience to understand (e.g., the concept of "angular separation" in astronomy vs. a description of how, when a car drives away from you, your eyes eventually cannot distinguish one tail light from the other — they simply blur together)

3.5 The *What* and the *How*

This lesson teaches students to distinguish the *what* they want to present from the *how* they will present it. All too often, when we want to design a presentation, we sit down at our computer and start creating and organizing slides. This approach misses the opportunity to carefully plan "what" will be communicated because decisions are immediately being made about the "how" of text, images, bullet lists, and such. It should be emphasized that presentations are a human media, and when slides are used with a presentation they are simply supporting media. This redirects the responsibility for communication from the slides to the presenter.

Once a general plan is in place for what information to present, it is appropriate to think more carefully about "how" pieces of the information will be presented. Will diagrams be used? Photographs? An analogy? A demonstration? Will some information simply be spoken? Assuming that the students' presentations will incorporate slides, integrating those slides into the presentation (instead of allowing the slides to be the presentation) is a significant challenge. There is a need to integrate: (i) spoken words, text, and images, (ii) what audience members are seeing and what they are hearing, and (iii) the presenter and any supporting media

The summary below discusses some strategies for effective presentation design, and pairs well with the storyboarding activity (Section 4.4).

- there are two methods of communication
  - reader-driven (e.g., online articles): readers "choose their own" adventure through the story, selecting what content they want to access and explore
  - author-driven (e.g., a talk): the author selects what material is included, and the audience has little input regarding what they get to hear
  - note that the middle ground between these includes journal articles and research posters, where the author decides on the presentation and content, but the reader chooses the order in which he/she reads it
- communication design focuses on two things
  - what (are you going to present), which is content development
  - how (are you going to present it), which is developing the method of presentation
- deciding on the *what*
  - what is your audience?
  - what is the context? (e.g., informal event, big keynote address)

    - what are *your* goals? (e.g., to get feedback on your ideas, to find collaborators, to impress people)
    - in essence, figure out *who* you are presenting to, what they *want*, and what they *need*

- once you have the *what*
    - brainstorm to collect all of your ideas — write down everything that comes to mind, and worry about editing it later (as in the storyboarding activity, write each idea on a small slip of paper)
    - storyboard
        * edit your ideas (i.e., remove the ideas/slips that don't fit the *what*)
        * develop your ideas (slips of paper) into a linear, logical narrative (i.e., a story that flows)
        * note that the slips of paper are *not* your slides (we'll get to these later)
        * present the storyboard to people, get feedback on the logic and narrative
    - answer the question: what would an audience member say your talk is about?

- thoughts one mess and confusion
    - increases when you are collecting ideas, and falls with editing
    - increases again while storyboarding
    - finally falls with feedback

- regarding the *how*
    - presentations are difficult because you need to integrate so many things (voice, appearance, slides, graphics, etc.)
    - establish a hierarchy of ideas in your presentation
    - get feedback (again — this is the second time you get feedback)

- some common mistakes
    - presentation-as-document: simply a collection of plots that would be better presented as a paper
    - slides-as-teleprompter: when a presenter simply reads the slides to the audience
    - slides-as-showcase: clip art images and pictures from the internet strung together

3.6 Distilling vs. Dumbing Down

When speaking to the public, it is easy to take shortcuts in our discussions by dumbing down the content. This is an unfair practice, as it indicates that we, as scientists, don't believe that the public can understand what we're trying to describe. Dumbing down content is, in essence, telling your audience that what we're doing is "too hard for non-specialist to understand." As science communicators, we know that this is never the case, and it merely takes some thought on the part of the scientist to make his/her ideas accessible to the public, or to "distill" their ideas down to the relevant, and simple, ideas that need to be communicated.

This lesson was given to our class by an award-winning astronomy instructor at the University of Washington, Dr. Toby Smith. Toby discussed how he goes from an idea that he wants to present in a 100-level course to the actual slides and content that he uses to describe the idea to his class. Maybe you have a lecturer or faculty member at your institution that you feel would be well-suited to such a discussion.

In essence, this lesson was a demonstration of the step-by-step process of distilling an idea, where the end results is a set of slides and content for a lecture to non-specialists. The idea that Toby wanted to discuss is, "Why is the capsule that delivered the Apollo astronauts to the Moon and back such a small portion of the rocket used to get them there?" As a scientist, Toby's starting point was the so-called Rocket Equation, which he used to do some derivations that answered his question.

Obviously, the complicated derivation wasn't appropriate for his audience, though, so he had to ask himself, "What parts of these equations do the audience need to understand, and how can I better explain it?". He identified a single formula as the only relation that he needed, and set about trying to figure out ways to explain this relation. He tried an explanation with a plot, which was an improvement, but which he still felt like wasn't quite right for his audience.

Plot in hand, Toby asked himself, once again, "What am I trying to tell my audience with this plot?" This led Toby to create a diagram that showed the energy budget of going to the Moon. The diagram showed how much energy is needed to go from: (i) Earth's surface to low Earth orbit, (ii) low Earth orbit to lunar orbit, and (iii) lunar orbit to the Moon's surface. The numbers indicated that most of your energy is used in simply getting to low Earth orbit.

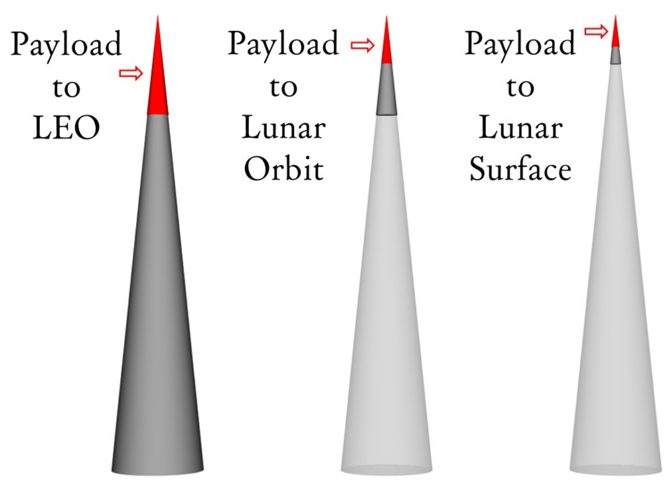

Figure 3.1: A graphic that demonstrates the pieces of a rocket responsible for taking astronauts from Earth's surface to low Earth orbit (LEO), from LEO to lunar orbit, and from lunar orbit to the Moon's surface (from T. Smith).

While we had come a long way from a dry derivation, Toby conceded that the diagram still did not explain why the return capsule is so small as compared to the rest of the rocket. The "eureka" moment came when Toby drew the connection between rocket size and the energy values shown in the previously-mentioned diagram. Toby related the pieces of the rocket that were dedicated to moving between the locations used in his diagram.

The end result was a series of slides that highlighted different pieces of the Saturn V rocket used to carry astronauts to the Moon (see figure). He would highlight the different stages of the rocket, and point out how far the fuel within that stage would take you on a mission to the Moon. A huge portion of the rocket is dedicated to getting you to low Earth orbit, which is because it takes a lot of energy to escape the gravitational pull of Earth. Subsequent portions of the rocket are smaller because the energy needed to take steps away from low Earth orbit is relatively small.

3.7 The Finer Points of Public Speaking

Many students are worried about certain aspects of public speaking. Specific worries include: What if I say "um" a lot? What if an audience member becomes aggressive during the Q&A? Do I fidget when I am speaking to a large crowd?

Before doing the impromptu speech activity (Section 4.9), have a classroom discussion on what worries the students about public speaking. Begin by having the students shout out all of their concerns, and make a list of these on the board. Once everyone has voiced their concerns, address each issue (listed on the board) by having the class discuss their own strategies or experiences that are related to the issue. In almost all cases, someone in the room will have had to deal with the problem at some point. In the cases where no one has experience, the class can brainstorm ideas for dealing with the issue.

In-Class Activities

Presented here is are a number of in-class activities that serve to strengthen the ideas and techniques learned in the various lessons in the curriculum.

4.1 First Day Introductions

On the first day of class, it is certainly useful to play some improv games and some name games (see Section 4.2). Another straightforward activity is to go around the room and have everyone say their name and describe what they research. The instructor should note all of the jargon that people use when describing their work. Once everyone has had their turn, discuss the various jargon terms that were used, and emphasize that, even in a room full of scientists, the language that was used led to confusion.

Following the jargon discussion, give everyone a second chance to describe their work. Allow them a few minutes to write down a new description, trying to avoid jargon, and then have everyone share what they wrote with the class. Collect these descriptions, and return to them towards the end of the course. After receiving some training, how do the students describe their work? How is it different from when they began the course? Have they developed a story for describing their research?

4.2 Improv Games

Improvisational activities are a key component of the Engage course. These activities serve a variety of functions, including: (i) getting the students comfortable in front of audiences, (ii) helping the students to think on their feet, and (iii) creating a comfortable classroom environment where students can trust one another.

Some great improv activities are described below, a few of which came from our interactions with Katherine Sather and Cluny McCaffrey of The Nature Conservancy. Before each improv activity, it is important to emphasize to the students why we are doing them. Some students struggle with improv, and many don't understand the utility of the exercises. For example, in the case of "Assassin" (described below), the goal is to help the students learn to form a direct link with their audience through eye contact.

Note that you can access descriptions of many, many improv activities online. If you are familiar with any improv troupes in your area, consider inviting them to a class to give instruction and lead games.

Assassin (This game is great on the first day of class.) This activity helps the students to learn one another's names, and has an emphasis on eye contact. Students form a circle. One person is the "assassin", and tries to "assassinate" someone by walking slowly towards them while maintaining eye contact with the "victim". The victim must say the assassin's name before the assassin tags him/her, and then the assassin chooses a new victim. If a victim is tagged by the assassin, he/she becomes the new assassin. The victim can be "rescued" by breaking eye contact with the assassin and establishing eye contact with another student, if this new student can say the assassins name before the assassin tags the victim, then the victim is rescued and the assassin chooses a new target.

Big Fish, Little Fish The students form a circle. The activity begins when one student says either "big fish" or "small fish" and makes a hand gesture demonstrating one of two possible fish sizes — either hands near one another or hands far apart from one another. The near gesture does not have to correspond to the "big fish" statement, and vice versa (tricky, huh?). The person to the right of whoever started must now (i) *say* the opposite fish size and (ii) *do* the opposite size gesture of the starting person. This is repeated, and the statements and gestures loop around the circle. For example, Student 1 says "small fish" and makes a big gesture, so Student 2 (to the right of Student 1) must say "big fish" and make a small gesture. Student 3 (to the right of Student 2) must now do the opposite of Student 2 — say "small fish" and make a big gesture. Increase the difficulty of the activity by having multiple interactions going simultaneously (e.g., have 2-3 students "start" the activity at the same time, so that many statements/gestures are going around at once).

Pass the Slap Students form a circle, hands and knees on the ground. Hands are interlocked with their neighbors. One person starts by slapping the ground, and the slap must pass, sequentially, around the circle. A level of complexity is added by allowing players to slap the ground twice, which reverses the direction that the slap is traveling. If you goof up the pattern (e.g., slap out of order), your offending hand is placed behind your back. You are "out" once both of your hands are behind your back.

Tappers and Listeners This activity is a great analogy to the poor way in which science is sometimes communicated — the scientist is "tapping", people are "listening", but no one understands what the scientist is trying to say. In the activity, the class is split into two groups, "tappers" and "listeners", and every tapper is paired to a listener. The tappers leave the room and agree on a simple song (e.g., "Twinkle Twinkle Little Star") that they will rhythmically "tap" (on their hands) for their partner. Listeners then try to guess the song.

Patterns The students form a circle. The first "pattern" is formed — starting with one person, he/she points to someone else in the circle, and then that person points to someone else. This proceeds until everyone has been pointed at, and the last person points to whomever began the pattern. Repeat the same pattern, pointing to one another, faster and faster. Eventually remove the pointing, and the pattern proceeds by individuals making eye contact and nodding. A second pattern is formed in a similar fashion, except now the players nod to one another and names a fruit (instead of pointing), and everyone should have a unique fruit. The pattern should be different from the first. Practice this pattern a few times, nodding and naming fruit. To complicate things, try to get both patterns going at once.

Nonsense The students form a circle. One person speaks a single syllable (e.g., bah), a second person (the next person in the circle) speaks a second syllable (e.g., goo), and a third person (next again in the circle) forms a word by combining these syllables (i.e., bahgoo), and creates a definition for it (e.g., the smell created by a rotting apple). The fourth, and final, person (next still in the circle) then uses the nonsense word in a sentence (e.g., In the autumn, the old apple orchard smells strongly of bahgoo.). This pattern of four segments goes around and around the circle, faster and faster.

4.3 Abstract Jargon

In this activity students are asked to identify jargon terms in scientific abstract from their own fields and other fields. This helps to remind students that what may not seem like jargon to them can actually be a confusing phrase to others.

Materials:

- students should have two copies of an abstract from a favorite scientific paper in their field (maybe even from their own work) — printing these may be incorporated into a homework assignment

The activity:

First, take five minutes and have the students read through one copy of the abstract that they brought to class, highlighting all of the terms and phrases that they think are jargon. Then have the students give the second copy of the abstract to a classmate from outside their scientific field. This classmate now reads the abstract and highlights all of the terms that he/she thinks are jargon. Return the second copy to the first student and let the students compare what *they* thought was jargon with what *others* thought was jargon. Are there terms that were only highlighted in one copy? Are there terms that may mean different things to scientists from different fields (e.g., “statistically significant”, “native”)?

4.4 Storyboarding Practice

In this activity students practice the technique of storyboarding, and get feedback on their storyboarded ideas. It will help students to narrow their message and become more aware of the many things they may need to explain to others about their topic.This activity should follow the in-class lesson on Storyboarding (Section 3.5), and can precede the assignment that further develops a student’s storyboard (Section 5.2).

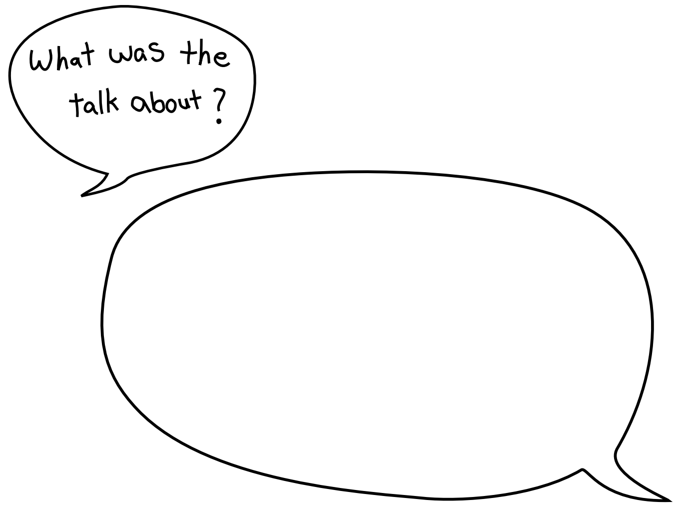

Figure 4.2: Students should be able to provide a 1-2 sentence response to this question regarding their public talk (courtesy M. Clarkson).

Materials:

- copies of the "What was the talk about?" cartoon for each student (see below)
- 20-30 small pieces of paper (roughly 3"×4") for each student
- crayons (or other colorful drawing utensils)

The activity:

Students split up into groups of 3-4 (try to make the groups interdisciplinary to help with feedback). Everyone takes a few minutes to identify "what their presentation is about" (see below). With that in mind, students begin sketching out ideas, concepts, and thoughts onto the provided pieces of paper. The crayons allow students to create pictures instead of just writing out text. Once the slips of paper have been consumed, the students start grouping these pieces of their storyboard by idea, and then the students organize the ideas/pieces into a logical progression. Finally, the students spend 30-60 minutes discussing their storyboards in their small groups.

4.5 Audience Considerations

Described here are two activities brought to us by the Pacific Science Center. The first, which reminds us what it is like to be curious about something, takes about two minutes per student in the class. The second activity, which reminds us of the frustration that can surround *not* understanding something, takes about a half an hour. Both of these activities should be followed by about 30 minutes of classroom discussion.

Curiosity The instructor brings a really interesting and intricate device (or toy) to class. For example, we used a complicated-looking, wind-up, metallic toy insect. The class forms a circle and passes the device/toy around. Upon receiving the device/toy, the student takes a few seconds to tinker/play with it. The student then responds to the following: When I see this, I think of...? I think this works by... A question I have about this thing is...

Frustration The class is divided into groups of three. Each group is provided three (closed) manila folders, one per each of the students. Contained inside the each folder is a very simple drawing (e.g., a sunset behind a hill that has a house sitting on it). These drawings cannot be duplicated within a group, but can be duplicated with other groups. Thus, you only need to come up with three simple drawings, and each group receives the set of three. It helps to use color-coded folders to keep the drawings separate. Each student in the group is also provided two blank sheets of paper, and each student is not allowed to see the drawings in his/her group mates' folders (except at the end of the stages described below). The activity proceeds in three phases, each of which involves one student, the "instructor", trying to get the other two students, the "audience", to reproduce the drawing that only the instructor can see inside his/her folder. The three phases are:

Phase 1 One student is the instructor. He/she tries to get the audience to recreate his/her drawing using only a description of the picture. No hand gestures allowed, and the audience is **not** allowed to ask questions. The instructor is **not** allowed to see what the audience is drawing. Give the groups about five minutes to do this, then allow the instructor to reveal his/her drawing.

Phase 2 This phase is similar to the previous, except a new student is the instructor. The rules change though — the audience is allowed to ask questions. The instructor still cannot make hand gestures, and still cannot see what the audience is drawing.

Phase 3 Same as above except with a new instructor. The rules now allow the audience to ask questions, the instructor to make hand gestures, and for the instructor to see what the audience is drawing.

4.6 Content in Print Media

This activity was brought to us by Lisa Grossman, a science reporter for New Scientist. By reading several different science stories on the same topic, students can see different approaches to choosing content.

Materials:

- copies of a short science story from three distinct sources but on the same topic (e.g., we use stories on "faster than light" neutrinos from several different news outlets)

The activity:

Have the students read (or read aloud) the three different news stories. Lead a discussion that compares and contrasts these stories. How did the authors deal with relevant background material? How were errors and uncertainties discussed? How did the authors introduce difficult concepts (e.g., really large numbers)? This activity can be extended/improved by assigning longer articles as at-home readings. In that case, you will have a lot more material to use and discuss during this activity.

4.7 Cocktail Party

This is a fun activity that involves role playing, and which allows students to practice their elevator pitches (see the assignment described in Section 5.2). It can either precede or follow the assignment on Audience Considerations (see Section 5.4). This activity also helps with audience considerations, and students are asked to view one another's science from different perspective.

Materials:

- name tags for each student in the classroom; half of the tags should be labeled "scientist", and the other half labeled with titles like "third grader", "engineer", "waitress", etc.
- drinks and snacks for the party!

The activity:

Students are given a name tag, so that half the class is a "scientist", and the other half have unique titles. A cocktail party commences, where the scientists mingle with the non-scientists. The scientist students discuss their research with the non-scientists, the it is the role of the non-scientist to role-play the title assigned to them. After 10-20 minutes of mingling, have the scientists and non-scientists swap name tags.

4.8 Analogies

Described here are two activities that focus on developing analogies. The first came to us via Katherine Sather and Cluny McCaffrey of The Nature Conservancy. These activities should precede the assignment on analogies (see Section 5.6).

Analogy Surprise In groups of 3-4, have students choose an article from the room (e.g., a notebook). The students take 3-4 minutes to list the attributes of the article (e.g., is red, can be used to store ideas, full of paper). Now for the surprise — tell the groups that they must use the attributes which they just listed as a source of analogies to give a science talk on a specific subject (e.g., storm drain run-off is bad for Puget Sound). Have the groups give their analogy-filled science talks to the rest of the class.

Analogy Practice Divide the class into groups of 3-4 (try to create interdisciplinary groups). Each group is assigned a key physical concept, and then the group must develop analogies that will help them describe their process to the rest of the class. Good concepts to assign include: plate tectonics, photosynthesis, RAM, DNA, probability distribution, nitrogen fixation, social media, gravity, virus, carbon cycle. Of course it is always good to pick concepts that students will be emphasizing or using in their public presentations.

4.9 Impromptu Speeches

This activity, brought to us by Allison Coffin (of Washington State University, and a Toastmaster) allows students to practice their impromptu speaking skills, which is an invaluable skill set when it comes to fielding questions on your research from the public.

Materials:

- a stopwatch
- a yellow slip of paper and a red slip of paper
- a list of questions that students will be responding to (e.g., “Where do you see yourself in five years?”, “What is your idea of a perfect vacation and why?”, “Why did you decide to attend grad school?”)

The activity:

A student stands up in front of the class and is asked to give an impromptu response to a question from the prepared list. The amount of time given for the response is two minutes, with the yellow slip raised as a ”thirty second warning”, and the red slip raised at the end of the time. Have someone in the classroom be the designated counter of filler words (e.g., “um”, “uh”). Once the student has completed his/her response, have the class provide feedback on the positive and negative aspects of the short talk. Also let the student know how many filler words he/she used. Have every student try the activity, and then have everyone try *again* so that they can try to improve based on the feedback they received. Students should try to emphasize storytelling in their responses.

4.10 Practice Talks

Towards the end of the course, the students should have assembled “draft” versions of the presentation that they will deliver to the public. Depending on how much class time you have, allow the students to deliver all or part of these talks, and use the form below so that other students can provide feedback. Make sure to allot about 10-15 minutes after each talk for discussion and feedback.

Presenter’s Name:

What was this presentation about?

Things I liked:

Things that could be improved:

Assignments

5.1 The Parts of *Your* Story

The purpose of this assignment is to get the students to think about how they would frame their research in the form of a story (see Section 3.3). The first part of the assignment is used to kick-off the organization of a public lecture series.

The assignment:

- Write a one-paragraph description of what you plan to present for your 30-minute public presentation. This information is going to be used to help plan and schedule the event, and will be read by non-scientists, so be sure to avoid overly technical terms. Please email this paragraph, as well as your name and a tentative title for your talk, to your instructor.
- Recall from class that the primary components of a story are the setup, the complicating action, the development, and the climax.
  - Identify these four elements in your own research.
  - Write a summary that places your work in the format of a story. Its okay if the summary is in bulleted form. These notes will be useful as we begin to plan and storyboard our presentations.
- Read N. David Mermin's "Whats Wrong with those Talks?" and be prepared to discuss how the general ideas of this article can be applied to your presentation.

5.2 The Sound Byte and Elevator Pitch

This assignment introduces students to the concept of a research "sound byte", which is a short, engaging statement about the student's work, and an "elevator pitch", which is a concise (paragraph-long) statement about their work. This pitch ties in well to the Cocktail Party activity (see Section 4.7).

The assignment:

- Read Chapter 1 ("Dont Be So Cerebral") from Randy Olson's *Dont Be Such a Scientist*. Be prepared to discuss this chapter in class. Pay close attention to Olson's comments on shifting the target of your communication from the head to the heart and gut. Utilize these ideas when completing the others tasks in this assignment.

- The Sound Byte. As the always-quotable Mark Twain so succinctly put it, a sound byte is "a minimum of sound to a maximum of sense". A sound byte should encapsulate the main point of a larger talk or speech into a quick and understandable statement. Mastering the sound byte is critical in our modern, fast-paced communication environment. Cornelia Dean (author of *Am I Making Myself Clear*) recommends having several on hand for potential interviews. An effective sound bite will: (a) last no longer than 30 seconds, (b) create instant intrigue, (c) be memorable, and (d) generate a result (e.g., interest) for the speaker.

  Heres an example of a sound byte from Randy Olsen: "I study the one species of starfish that spawns in the dead of winter instead of during the spring season." It's enough to establish the tension and create intrigue about this most unusual starfish.

  Prepare three sound bytes about your research that you will test out in next week's class. Please bring these on a sheet of paper that you are willing to turn in.

- The Elevator Pitch. An elevator pitch is a concise explanation of what you're doing and why. Ideally, it could pique someone's interest in the time span of a short elevator ride. Randy Olsen (as you have read) notes that an elevator pitch should follow basic structure of a story: set up your subject, give it a source of tension, reveal a possible solution, and combine all of the content to release the tension. Notice how this follows the standard story format of set-up, complicating action, development, and climax. Note that Olson discusses an example of an elevator pitch on pages 115-116 of your reading.

  Tim Row of the Cambridge Innovation Center states that a good elevator pitch should follow these rules:

  - talk in a way your grandparents could understand
  - don't expect the listener is an expert or knows scientific jargon
  - prove that you and your team are experts
  - engage the listeners emotions from the start
  - show that what you are doing matters

  Brainstorm your set-up, tension point, development, and tension relief. Also, brainstorm a possible hook that will draw an audience in. Combine these ideas into an elevator pitch that you will present to the class next week.

5.3 Storyboarding

The students are asked to produce an end-to-end storyboard for their presentation (see Sections 3.5 and 4.4).

The assignment:

- In a previous assignment, you placed your research in the format of a story (setup, complicating action, development, and climax), and in class you have learned about the importance of storyboarding in preparing an effective presentation. Its now time to pair these two concepts – create a rough, end-to-end storyboard for your public presentation (maybe 10-20 frames).

  If this seems overwhelming, recall that a "standard" story spends roughly equal amounts of time on setup, the complicating action, development, and the climax. A story doesn't *need* to follow these timing rules, but it could prove productive to begin your storyboarding with these four sections at about seven minutes apiece. Once this rough outline is in place, you can start sub-dividing the sections into your storyboard. Ask yourself the following questions, and place your responses into the storyboard. In all cases, aim to communicate to your audience's *heart* and *gut*.

  - What key ideas do I need to provide in my setup?
  - Who are my primary characters, and what goals do they have?
  - How have my characters' goals shifted as a result of the complicating action?
  - What is the unique/different approach that my characters must take?
  - How can I incorporate suspense, action, and delay into my development?
  - How can I frame my climax in terms of a protagonist accomplishing a goal?

5.4 Being Considerate

This assignment asks students to consider possible audiences for their presentation, and has the students think about how they would approach giving a presentation to these audiences. This assignment should follow the activities in Section 4.5.

The assignment:

- A recent class was all about audience and audience considerations. Everyone is familiar with the concept of an "audience". We have all been part of an audience during lectures, conferences, and speeches. What may be less familiar is the idea of connecting with your audience. We all recognize when a speaker fails to connect with their audience, and such a failure can lead an audience to believe a topic is boring or over their heads. As scientists trying to engage the community at different levels, it is critical that we carefully consider our audience.

  Randy Olsen points to several key mistakes scientists make when communicating with an audience:

  - We are "too cerebral". That is, we are rational and analytical and can ignore the emotional and human element of our audience.
  - We often talk-down to, or assume ignorance in, our audience.
  - We can be "unlikable" when we are overly critical or negating.

  Olsen uses a passage from John Steinbeck's *The Log from the Sea of Cortez*. To illustrate this "unlikeability" which is paraphrased here:

  A sea monster has washed up on the beach of Monterey, and a wave of excitement has swept the town. People have thronged to the beach to see this monster, tantalized by the chance to catch a glimpse of the unknown, the monstrous. When the crowd arrives at the beach they find the monster, a note pinned to its head saying "Dont worry about it, it's a basking shark" signed by Dr. Ralph Bolin of the Hopkins Marine Station.

  To me, and perhaps to you, Dr. Bolin did the right thing. He approached the scene rationally and dispelled the air of mysticism surrounding the sharks corpse. No doubt he acted out of good will. But, to the towns people in the book, he was nothing more than a stodgy old party-pooping know-it all.

  Scientists should strive to turn accuracy into something engaging. Scientific training leads us to be negating, but most audiences find this off-putting, which ultimately leads to disengagement and a sense that scientists, and therefore science, is no fun at all. By carefully considering our audiences, we can eliminate some of this miscommunication, and target our messages carefully, and at the right level.

  What to do:

  - Consider your potential audiences and come up with a list of 3 (e.g., elementary school students, fellow scientists, etc.). Make sure one of them is "the audience at my public presentation".
  - For each, respond to the following (type this up, and bring it to class): How do *you* see your audience, and what assumptions are you making? How does your audience see you? What is your goal for the given audience?

5.5 Presentation Contents

Students often struggle with what they "need" to put in their presentations. How much background? Should I describe my statistical techniques? (No.) In this assignment, the students listen to a radio show and begin to work out exactly what details need to appear in their presentation. The questions below pair well with the in-class activity on Choosing Content (Section 4.6).

The assignment:

- Read pages 104-118 from Randy Olson's *Dont Be Such a Scientist* (this is a small part of his chapter "Dont Be Such a Poor Storyteller"). Be prepared to discuss this chapter in class. Keep his section on "Accuracy versus Boredom" in mind will performing the second part of this assignment.

- The Devil is in the details, and science is no different. How do we successfully incorporate scientific concepts in a talk aimed at the general public without overwhelming them with mundane details? One program, Radiolab, has sought to do just that. This week, we focus on one podcast from Radiolab, and dissect it while reflecting on our own science and the content that is integral to understanding our topics.

  - Listen to the "Animal Minds" podcast of Radiolab, found here:
    http://www.radiolab.org/2010/jan/11/
  - Answer the following questions (to be turned in):
    - What material did Radiolab leave in regarding the science of animal cognition?
    - Did they attempt to explain any difficult concepts regarding animal cognition?
    - Were they successful in their explanations, why or why not?
  - Apply these questions to your public presentation (to be turned in):
    - List all of the material that is critical to understanding your research.
    - Of these concepts, which MUST you include in your talk?
    - Which of these necessary concepts are particularly difficult to explain?
    - Can you think of any methods that might help you explain these concepts?

5.6 Distillation and Analogies

The assignment helps students practice the distillation of certain key ideas that will appear in their presentations, and also has them develop some analogies for these ideas. This work should follow the in-class lessons on Distilling vs. Dumbing Down (Section 3.6), and the activity on developing analogies (Section 4.8).

The assignment:

We recently learned about a pair of important concepts. The first, distilling versus dumbing down, is something that scientists must always worry about when preparing a presentation for the public. We have a variety of key concepts and results that we wish to discuss by distilling them into their essential components. Dumbing these ideas down insults the audience, and can lead to the misinterpretation and misuse of your statements.

The second important concept was the use of analogy when explaining a complicated idea. Analogies are especially useful when you are attempting to distill a key idea. A great science communicator should see analogies for all of the scientific concepts that he/she works with. Being able to produce or recall an analogy at any point in a discussion (e.g., during the questioning period after a presentation) is an invaluable skill.

Please address the following statements/questions, and turn them in next week in class.

- Identify two important concepts that you will be addressing in your public presentation. These should be things like "what a bacterium is", "machine learning", or "how trees can prevent soil erosion".
- For each of these two concepts, write a paragraph that defines the concept, explains it as you would to another scientist, and states what it is that your public audience *needs* to know about the concept.
- Using what you wrote for the questions above, think of some analogies (at least one per each of the two concepts) that will help you with describing this concept to your audience. Think of these analogies as tools to help you go from the complex and complicated statements (that you would use when talking to another scientist) to something that could be easily understood by an audience member in your public talk.

Concluding Thoughts

You've taught the course and trained a cohort of students to be effective science communicators, but you're not done yet! As was mentioned earlier, the Engage Program is more than just the "theory" of science communication, it also includes the "practice" of science communication. Every student of every Engage cohort at the University of Washington gives a 30 minute long science presentation to the public, and we want to encourage you to do the same.

When assembling a lecture series, there are two main things that you need to consider: location and advertising. When deciding on the former, consider what kind of audience you would like to have. If you hold the lecture series on a university campus, you will mainly be speaking to undergrads and faculty. Off-campus locations will probably allow you to reach a wider audience. Such locations could include the university bookstore, a pub (as the "Science on Tap" series has done), or a larger venue (e.g., we have used Seattle Town Hall for one of our series).

Paying for a location can be an issue. A university may want to charge you fees to use a classroom, or a university bookstore could ask you to rent the space you want to use. It's usually easy to avoid having to pay for the space. You may be able to convince a university to donate the space if you tell them that your series will be promoting science done at the university, our you could reserve a room on campus as an official "class" to which the public happens to show up.

Collaborations work well, too, as we've found with Seattle Town Hall. They've been great about pairing our speakers to "main events" going on at Town Hall, allowing people who attend the main event to come to our talks for free. A deal worked with the University of Washington Bookstore has allowed UW students to get in for free. If you go down a similar route, it's important to remember that timing is everything. Leading the main event doesn't work very well, as most people will be arriving for the appropriately-named main event. If you follow the main event, try to get your talks going as quickly as possible, since people may leave after the main event not knowing about the talk that follows.

Depending on the setting, you may want to consider having back-to-back Engage presentations. This isn't necessary if your talks are paired to larger events, but will be necessary for stand-alone events. Many people may not be willing to come out for one 30 minute talk, so try to entice them by having two speakers give 30 minute presentations (plus time for Q&A).

Advertising your speaker series can be very difficult depending on your budget. If your series is paired to larger events (like our series at Town Hall), then you may simply end up incorporated into the advertising for the larger events. If you are speaking at a pub, you may need very little advertising since you will capture whatever audience is there when your speakers go on.

If your events are stand-alone, then advertising is a must. Consider contacting your university's press office to see what they can do to help you. You can try getting ads in the university's newspaper or on student radio. Local radio will reach a wide audience, but can be pricey. We've also experimented with posters for our lecture series. We designed the poster and paid a local business to print and distribute them. The service was inexpensive (a few hundred dollars), but didn't seem to reach too many people.

Social media can take you a long way. Create a webpage for your Engage-like program, and have your students blog on the site. Create a Twitter account and a Facebook page. Along with all of this, remember to take pictures while in the classroom — these will be great to post online, or to use on a conference poster or in a talk (if someone should decide to present on your experience at a conference).

Appendix — Readings

WHAT'S WRONG WITH THOSE TALKS?

N. David Mermin

My friend Professor Mozart recently ran across some advice to young physicists on how to give talks (James C. Garland's article in PHYSICS TODAY, July 1991, page 42). He came to me seething with indignation. "What's the problem, W. A.?" I asked. "I thought Jim Garland spelled out concisely and effectively just about everything the novice ought to take into consideration."

"As you say," he snarled, "it was a precise recipe for how to produce a contemporary physics talk—an almost perfect codification of all the ingredients."

"Well what more could you ask?"

He gave me a look of withering scorn. "The contemporary physics talk is a disaster," he proclaimed. "The only pleasure it affords is the relief that washes over you as you realize, finally, that perhaps the end is in sight. To assemble a respectable audience you have to bribe people with cookies and muffins. You must offer gallons of coffee to those honorable enough not to take the food and run, to help them maintain consciousness during the next hour. The article in PHYSICS TODAY did a masterful job of passing on to future generations everything necessary to maintain this dreary art form."

"You're unfair," I reprimanded him. "There are too many things about lecturing that you, an experienced speaker, simply take for granted. If you think the article gave young physicists bad advice, have you anything better to offer?"

"They were not given bad advice. They were given excellent advice for making the best of an inherently hopeless situation. But pretending that the standard physics talk of today is an acceptable form of communication breeds hypocrisy in the old and experienced and nurtures self-doubt in the young and innocent, who not only have to undergo the wretched experience of attending physics talks but also torture themselves worrying why they're not enjoying the ordeal. I would have urged speakers to get to the root of the problem."

"And just what might that be?"

Without another word he thrust into my hands a battered handwritten manuscript covered with coffee stains and smeared with muffin crumbs, evidently labored over during many hours of intolerably dull seminars and colloquia. Then he walked off in a huff.

Though appalled by some of the opinions expressed in the document he handed me, I reproduce it below in its entirety as a counterbalance to the conventional wisdom.

David Mermin is a professor of physics at Cornell University. The first physics colloquium he ever gave was so dreadful he was not invited back for 22 years.

Advice to Beginning Physics Speakers (and Intermediate or Advanced Ones)

William A. Mozart

***Bill Mozart** is Rachmaninoff Professor of Physical Science somewhere in the depths of central New York. He has been forced to embed these precepts in another's article, because PHYSICS TODAY discriminates against imaginary people.*

If you have taught physics you know it is virtually impossible to write too easy an exam. Yet nobody acknowledges that the same is even more true of the physics talk. It is absolutely impossible to give too elementary a physics talk. Every talk I have ever attended in four decades of lecture-going has been too hard. There is therefore no point in advising you to make your talk clear and comprehensible. You should merely strive to place as far as possible from the beginning the grim moment when more than 90% of your audience is able to make sense of less than 10% of anything you say.

It is in the nature of physics talks that they should be boring and confusing. You, the speaker, struggled through ten years of college and graduate school to reach the point where you could do research in your chosen area, acquiring arcane skills available to only a narrow range of practitioners. To attempt in the space of an hour to provide your audience with even the minimal background necessary to savor your recent research achievements is a doomed undertaking.

Yet we do give talks. Why? Only when this is understood can there be hope of producing an acceptable lecture.

The best reason to lecture on your work is that it affords you the opportunity to rediscover why you did it. The most important question to ask yourself in preparing your talk is why on earth any physicist might be interested. This is dangerous: There is always the risk you will find no answer. But that is not necessarily a cause for alarm. Often when working on a problem for a long time, one does indeed forget what first led one into that line of endeavor, so if at first you can find no answer, think some more. What is there in the subject to capture the imagination of one lacking your highly specialized skills?

Give yourself a week. If you still can find no reason why anyone not directly involved in the work should find it anything but tediously obscure, then you should find something else to talk about. Indeed you might then seriously consider finding another area of research. Often merely preparing to give a talk can yield up such beneficial insights without your ever actually having to deliver the talk.

But suppose you do remember why you got into your current line of research. If you succeed in conveying that early freshness and excitement to somebody else, your talk will be an unqualified success, even if you never manage to describe a single one of the splendid things you uncovered when the project was well under way. Those interested in such technical matters will ask you questions in private. For no matter how detailed you might be tempted to make your talk, it cannot possibly be detailed enough for those few who are knowledgeable enough to appreciate such refinements. And no matter how basic and elementary you make your treatment of those fascinating technical accomplishments, virtually none of them will penetrate the minds of the overwhelming majority of your audience. Your only goal must be to furnish ordinary physicists with some modest glimpse of what sustains your own interest in your subject.

What brings even well-intentioned efforts to grief is the misconception that it is necessary for speakers to talk about their own contributions. There is no need to say anything whatever about what you did yourself. Your personal work in the field qualifies you to give a talk only because it may have led you to discover how to break through the formidable barriers preventing the subject from engaging the interest of outsiders. If you can manage to do this *and* encompass a contribution or two of your own, that is fine. But if your own contributions are unfit for public display in such a forum, that too is fine, provided you do not persist in displaying them anyway. This should be kept in mind even when designing "job talks" or presentations at specialized conference sessions. Sometimes you have no choice but to speak of your own work, but even then it is best to devote the greater part of your talk to giving the clearest possible context for that contribution.

Never, ever, have I heard anybody complain about a talk on the grounds that "I understood everything in it." People feel good after talks they understand. Even those few people who hear nothing they didn't already know can derive substantial enjoyment from hearing their subject presented well. The most important thing your talk can do for such experts is to give them an opportunity to learn how to do better in their own talks.

Other points to keep in mind:

▷ Humanists, who take words more seriously than physicists do, often read their talks from a prepared text. When the talk is delivered with animation and impromptu asides, the results can be spectacular, for the written language is more powerful and concise than informal speech, and a richer and more attractive medium. Most physicists deem it undignified or unsporting to read a prepared text. Rubbish!

▷ The physics talk has, in any event, evolved toward the reading of a prepared text, but in an entirely unsatisfactory way. Many physicists do read their talks, not from a paper text, but from a sheet of transparent plastic projected on a screen. This combines the worst of both approaches: The spontaneity of improvisation is lost, but the elegance of writing is not achieved, since the verbal contents of the plastic sheet are fragmentary stammerings, not written language. To make things worse, text on plastic sheets can be read by an audience faster than the speaker can anticlimactically deliver it, unless the abominable practice is employed of covering up most of the plastic until the moment of revelation. Sheets of plastic must never be used to convey the purely verbal, which should be either spoken extempore or read aloud from a paper text.

▷ Sheets of plastic are only for illustrative figures, graphs or data, and unavoidable elementary mathematical analysis in the absence of a blackboard. Even when so used they almost always have too much on them. Many in your audience will have an unobstructed view of only the upper half of the screen, and many will be seated quite far from it. You must therefore put very little on each sheet, leave the lower half empty and make everything extremely large and uncluttered. If your analysis or diagram is too intricate to present in this way, it is too intricate to be in a talk at all. Just as one should go through a manuscript many times, ruthlessly cutting the redundant, so too should one keep redesigning a plastic sheet to reduce its contents to the bare minimum. You will be present when the sheet is on display. Most details are better supplied orally.

▷ We are fortunate to live in an age of informal dress. When giving a talk, wear whatever makes you comfortable, remembering only that a filthy or outlandish costume may be viewed by your audience as a sign of disrespect or incipient lunacy. Do not worry whether all your buttons are buttoned. Once you start down that perilous path you can wonder whether there is ketchup on your nose, a large chalky smudge on your back or a piece of stickum with a coarse message maliciously affixed to an inaccessible part of your person. Assume that if you are in disrepair somebody in your audience will have the kindness to call it discreetly to your attention, permitting you to fix the problem on the spot. If it's not called to your attention, it's not a problem. If it is, simply say, "Ah, mustard on my ear? Sorry about that," wipe it off and continue.

▷ On those few occasions when a physics talk delves into the history, sociology or social psychology of the subject, the audience wakes up and listens. Though most professional journals frown on such digressions, they are entirely appropriate in a lecture. Reading aloud from the reports of hostile referees, for example, almost invariably rouses an audience from its stupor as well as giving you a rare opportunity to make it vividly and painlessly aware of your own contributions.

▷ The ubiquitous heavy-handed concluding summary should be omitted; a talk should tell such a good story that a summary is uncalled for. Imagine *War and Peace* ending with a summary. There is no better way to make an audience happy than briskly finishing a talk five minutes earlier than it expected you to. Like this. ■

ONE

Don't Be So Cerebral

In 2000 Premiere *magazine ran an article about the making of the movie* The Perfect Storm. *The actor Mark "Marky Mark" Wahlberg talked about filming scenes off the coast of Massachusetts and told of glancing over his shoulder and spotting gray whales passing nearby. Even though it had been six years since I had resigned from my professorship, the scientist's eye never fades, and I couldn't help but be tripped up by that detail. I wrote a letter to the editor of the magazine explaining that those whales were either something other than gray whales (long since extinct in the Atlantic Ocean) or stunt doubles flown in from the Pacific Ocean. They published it. A couple of months later I ended up at a Hollywood party, spotted the issue of* Premiere *with my letter, proudly said to the group, "Hey, everybody, listen to this," and then proceeded to read my letter to the editor aloud. When I finished I looked up, beaming, but instead of applause I saw expressions of "Huh?" My best friend from film school, Jason Ensler, finally broke the tension by saying, "You know, the thing about Randy is, half the time he's like the coolest guy any of us know in all of Hollywood. But the other half of the time . . . he's a total dork."*

So we begin with the crazy acting teacher and some of the simple concepts she pounded into our heads night after night. There was one that emerged supreme seven years later, when I returned to working with academics. It is so simple and yet so powerful that I choose to start this first chapter with it. Most of what I have to say descends from this notion.

Here it is . . .

The Four Organs Theory of Connecting with the Mass Audience

When it comes to connecting with the entire *audience, you have four bodily organs that are important: your head, your heart, your gut, and your sex organs. The object is to move the process down out of your head, into your heart with sincerity, into your gut with humor, and, ideally, if you're sexy enough, into your lower organs with sex appeal.*

That's it. Others have heard me mention this in talks and put their own spin on it—talking about the chakras and "mind body spirit" and other sorts of New Agey gobbledygook. Also, there's vast work in the field of psychology exploring these sorts of dynamics. Carl Jung talked about personality types, and the Myers-Briggs Type Indicator, developed during World War II, explores this vertical axis of powers in the body. But, for our purposes, let's keep it simple and free of psychobabble. If you've had lots of classes in psychology, you may find this annoyingly simplistic. If not, I hope you'll find it as useful as I have.

It's about the difference between having your driving force be your head and having it be your sex organs. There *is* a difference.

Let's begin by considering each of the four organs.

The *head* is the home for brainiacs. It is characterized (ideally) by large amounts of logic and analysis. When you're trying to reason your way out of something, that's all happening in your head. Things in the head tend to be more rational, more "thought out," and thus less contradictory. Academics live their lives in their heads, even if it results in sitting at their desks and staring at the wall all day, as I used to at times. "Think before you act" are the words they live by. When they ask, "Are you sure you've thought this through?" they are reflecting a sacrosanct hallmark of their entire way of life.

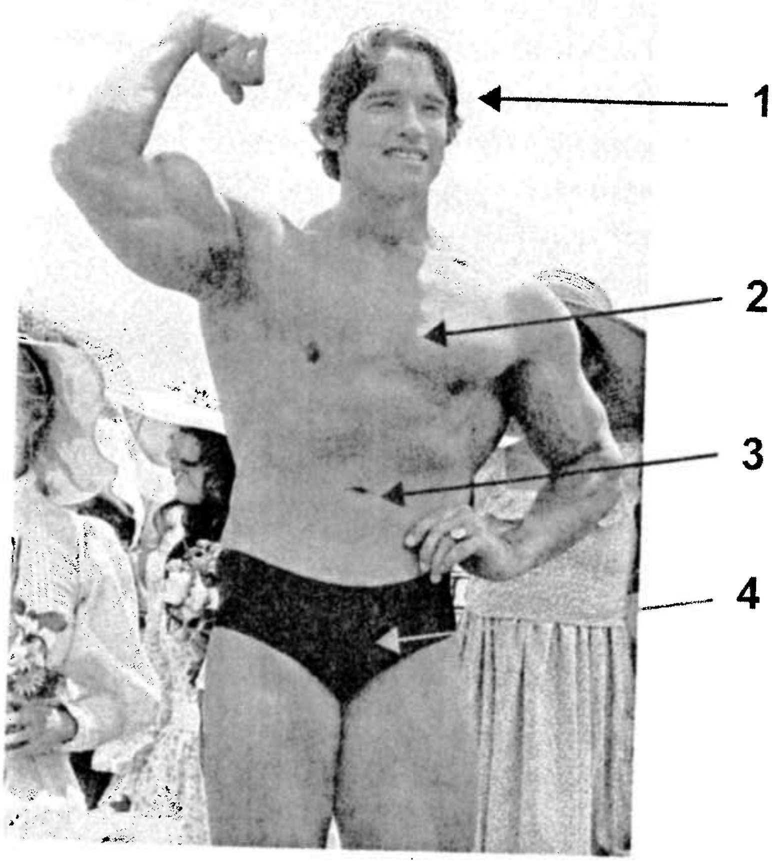

Figure 1-1. The four organs of mass communication. To reach the broadest audience, you need to move the process out of the *head* (1) and into the *heart* (2) with sincerity, into the *gut* (3) with humor and intuition, and, ideally, if you're sexy enough, into the *lower organs* (4) with sex appeal. Photo courtesy of © Mirkine/Sygma/Corbis.

The *heart* is the home for the passionate ones. People driven by their hearts are very emotional, deeply connected with their feelings, prone to sentimentality, susceptible to melodrama, and crippled by love. Religion tends to pour out of the heart, and religious followers feel their beliefs in their hearts. Actors usually have a lot of heart. Sometimes annoyingly so. In an episode of *Iconoclasts* on Sundance Channel, you can see it when Renée Zellweger (heart-driven actress) and Christiane Amanpour (head-driven reporter) visit the World Trade Center memorial in New York City. Renée is overflowing with emotion, crying for the people who died, agonizing over the tortured fate of humanity, practically throwing herself to the pavement in empathetic agony, while Christiane offers up analytical, dry-eyed, rational commentary on how sad it is that humans do terrible things like this (which she's seen firsthand all around the world in her reporting). It's a perfect side-by-side comparison of head versus heart.

The *gut* is home to both humor and the deeper levels of instinct (having a gut feeling about something). We're getting a long way away from the head now, and, as a result, things are characterized by much less logic and rationality. Humor tends to come from the gut, producing "belly laughs," but also is extremely variable and often hard to understand. There's nothing worse than someone trying to explain why a joke is funny.

People driven by their gut are more impulsive, spontaneous, and, most important, prone to contradiction. Where the cerebral types say, "Think before you act," the gut-level types say, "Just do it!" When things reside in the gut, they haven't yet been processed analytically. For that reason, when people have a first gut instinct about something, they generally can't explain why they have the instinct, where it comes from, or how exactly it works. As a result, if you quiz them about it, you're going to find they are full of contradictions. You'll end up saying, "But wait, you just said X is the cause, and now you're saying Y is the cause." And they will respond with crossed eyes and a look that says, "I know! Can you believe I'm so confused?" And yet they are still totally certain they understand what's going on.

We heard a lot about the gut-versus-head divide during the 2004 presidential race between George W. Bush and John F. Kerry. Bush even proudly spoke of how he based much of his decision making at the gut level. He told author Bob Woodward, "I'm a gut player. I rely on my instincts." Not surprisingly, Bush's presidency was characterized by a great deal of contradiction.

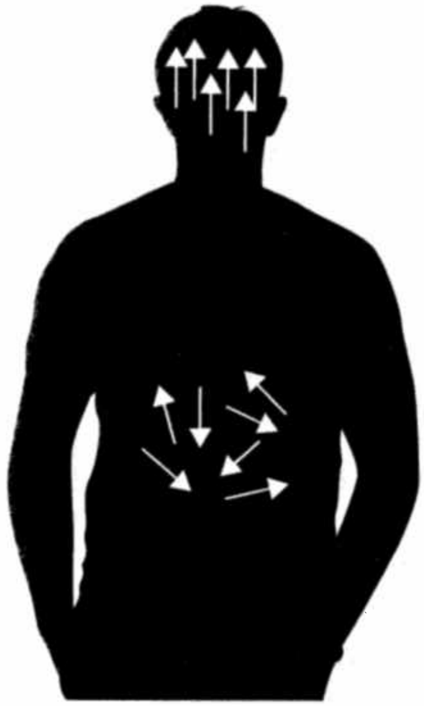

Figure 1-2. Intuition resides in the gut and tends to be full of contradiction. When the process is moved up to the head (intellectualized), the information is channelized, making it more consistent and logical.

At the bottom of our anatomical progression we have the naughty *sex organs.* As soon as you finished reading this sentence, you probably smiled for reasons you don't even begin to understand. All I have to say is "penis" and you're either physically smiling or internally smiling. Why is this? Well, let's ask Bill Clinton—remember him? He's the man who obliterated his entire historical legacy thanks to this region. Let's ask the countless men and women who, over the ages, have risked and destroyed everything in their lives out of sexual passion.

There is no logic to the sex organs. Look at those arrows in the gut in figure 1-2. Now picture them moved lower and spinning in circles. You're a million miles away from logic in this region. And yet the power is enormous, and the dynamic is universal.

Not universal, you think? Some people have no sex drive? That is, of course, impossible to test, but one thing worth taking a look at is the life of the novelist and philosopher Ayn Rand. She was one of the most prominent popular figures to suggest it is possible not to be driven by such irrational forces. She authored the massively best-selling *Atlas Shrugged* in the 1950s and founded her "objectivist" school of thought and way of life on the principle of suppressing one's irrational side. And guess how her life turned out. She eventually got eaten alive by her sex organs.

Seriously. One of the greatest books I've ever read was Barbara Branden's biography of her, *The Passion of Ayn Rand*. In a nutshell, Barbara and her husband, Nathaniel, became followers of Rand, went to work for her, and believed and lived every word of her teaching about living an objectivist life—not allowing oneself to be controlled by pointless, frivolous, irrational thoughts and feelings. Rand's objectivist school of thought in the 1950s grew to enormous popularity; its followers even included former Federal Reserve chairman Alan Greenspan. And then . . .

Rand ended up secretly boinking Nathaniel for a couple of decades. When he dumped her, Rand turned vitriolic, and the public began to catch glimpses of the insanity she was living (proof that the story wasn't just Branden's fantasy). Total hypocrisy of the highest magnitude—telling the world to suppress its irrational side while viciously shoving the man who had scorned her out of her institute. According to Branden, Rand went to her grave still simmering with rage over it.

So don't even begin to think that the lower organs are not a universal driving force, for everyone from the local FedEx delivery guy to the president of MIT. And once you've processed that thought, you can appreciate the age-old adage "Sex sells." It's the truth, mate. If you are fortunate enough to get your communication down into that region, you can connect with almost every living human—even the most anti-intellectual NASCAR fan. Who doesn't like Brad Pitt and Angelina Jolie? They're sex-eeeee.

Too Heady: The Less Than One Campaign

Now, if we consider these organs, we start to see some fundamental differences in the members of the mass audience. The lower organs include everyone, but as we move upward, our audience narrows. There are people who pretty much respond only to sex and violence. Not much of a sense of humor, not much passion, and zero intellect. Once you move above the belt, you've lost them.

But you still have the attention of a lot of people through humor—most folks love humor. But then you move higher and lose that element. Well, with the heart you still have actors and the religious folks. But then you move up above that, into the head, and who do you have left? Just the academics. Which is okay, but the point is that you're communicating now with a very small audience. You've left most of the general public out of the story.

So this is the fundamental dynamic. And it began to resonate with me in 2001 as I drifted back from the Hollywood environment I had been immersed in since leaving academia in 1994. I started working with academics and science communicators in ocean conservation. And as I did, the words of that acting teacher began echoing back at me.

I learned of a large project called the Less Than One campaign. The idea was built around someone's revelation that less than 1 percent of America's coastal waters are protected by conservation laws. Someone thought, "If we can communicate this factoid to the general public, when people hear it they will think about how small 1 percent is and they'll be outraged."

Well. They should have called it the Less Than Outraged campaign, since that's what happened with the general public. The Less Than One campaign opened its Web site in July 2003. It had a number of ill-conceived media projects (I'll talk about one of them in chapter 4), and, to make its short story short, by July 2004 the site was gone and not a trace of the project could be found on the Internet.

Suffice it to say, the masses simply do not connect with "a piece of data" (i.e., a number). Could you imagine a presidential candidate making his campaign slogan "More than 60 percent!" with the explanation that, if you elect him, eventually more than 60 percent of the public will earn more than $30,000 a year? For some reason I just can't see the crowd at campaign headquarters shouting, "More than 60 percent! More than 60 percent!" Sounds like something from a Kurt Vonnegut novel.

No, in fact groups connect with simple things from the heart—"A new tomorrow," "We've only just begun," "Yes we can." You just don't see a lot of facts and figures in mass slogans, unless they've been crafted by eggheads.

By now you may be thinking, "What's this guy got against intellectuals? He's calling them brainiacs and eggheads." Well, I spent six wonderful years at Harvard University completing my doctorate, and I'll take the intellectuals any day. But still, it would be nice if they could just take a little bit of the edge off their more extreme characteristics. It's like asking football players not to wear their cleats in the house. You're not asking them not to be football players, only to use their specific skills in the right places.

Kicking Flowers: The Value of Not Thinking Things Through

I'm criticizing overly cerebral people here, yet we obviously know there is a value to working from the head most of the time. Educated people make great inventions, create important laws, run powerful financial institutions. Clearly it pays to think things through so that everything is logical, fair, and consistent. But what's not so obvious is the value of sometimes *not* thinking things through.

Spontaneity and intuition reside down in those lower organs. They are the opposite end of the spectrum from cerebral actions. And while they bring with them a high degree of risk (from not being well thought through, obviously), they also offer the potential for something else, something magical, something that is often too elusive even to capture in words. And because they are so potentially effective, they are the focus of the rest of this chapter.

I learned about the power of spontaneity the hard way—by getting yelled at in that acting class. I eventually got to see it up close and personal as I began to realize I was a lousy actor. And the reason for my being a lousy actor was that I was . . . too cerebral. I thought too much.

Let me tell you specifically how I would get to see it. Night after night we would do acting exercises in which one person pretends to be at home and the other person comes home. On the edge of the stage was a fake wall with a door that the person coming home would enter. So, for example, I would be the guy at home, maybe working on balancing my checkbook, and my "wife" would come in after a long day of work. We would get into an argument over something, and then, right in the middle of the scene, I would accidentally do something that wasn't in the plan—like, let's say, knock over the vase of flowers on the table. The contents would spill all over the floor. I would look down. And then, being the highly cerebral former academic, I would start thinking.

I would think, "Wow, I just knocked over the flowers, that wasn't supposed to happen, we're supposed to be arguing over the wrecked car, how would this clumsy act I just did fit into my character's tendency to—"*and then, blaaaaah,* the teacher lady is up and screaming in my face: "*Stop thinking! Do something!* Nobody wants to watch you stand up here and think. You're like a statue. Do you want to watch a play full of statues? *Act!*"

Then a similar thing would happen with one of the younger, less cerebral guys. When he knocked over the vase, he would immediately kick it like a football and shout, "*I hate flowers!*" And the audience would burst out laughing and cheering, and the crazy acting teacher would scream at him, "*Why did you do that?*" and he would reply, "*I don't know!*" and she would scream with joy, because *that* was a spontaneous moment in which you could feel the magic.

And *that's* what I was so bad with. I would just think too much. The fact is, if she let me go long enough, I would eventually look at the vase and say to my "wife," "Your bad driving upsets me so much I end up doing things like knocking over vases of flowers." And the audience would snore. I would have provided a well-thought-out and reasonable response to the spilled flowers; it just would have lacked that spark of energy that the other, more spontaneous performance provided.

That's the deal with spontaneity. It gives a wonderful energy that audiences love. And, by the way, it has become the core and backbone of a major shift in the entertainment world over the past decade.

The Shift to Unscripted Entertainment

I finished that acting class in 1996. I never had any intention of becoming an actor (I did it to improve my directing skills), but all the other kids in class headed off to pursue acting careers.

By early 1999, though, they began showing up on my doorstep, depressed. In Hollywood, the month of February is generally known as "pilot season." That's when the networks cast the pilots they will shoot—whether half-hour sitcoms or hour-long dramas. For actors it's a frantic time in which they may have four or five auditions a day, causing them to drive wildly back and forth between Hollywood and Burbank. But suddenly in 1999 the number of auditions dropped significantly, and my aspiring actor friends felt the pinch.

They would come to my apartment in Beachwood Canyon, right beneath the Hollywood sign, for lunch. We would sit on my front porch, and I would commiserate with them. "There are hardly any parts this year," they would say.

So where do you think all these acting roles went? Were they lost to outsourcing? Shipped overseas? Displaced by computer-generated actors? Nope.

They were lost to a new trend—reality shows, which are part of a larger category known as "unscripted entertainment." A whole wave of these shows hit the scene around the turn of the century, including *Survivor*, *Big Brother*, and all the other crazy shows you now know. But as quickly as my friends got depressed, they also heard a rumor that brought some relief—that it was only a fad—that within a couple of years reality shows would run their course, lose popularity, and never be heard of again.

Well . . . it's a decade later, and guess what? That rumor was way off the mark. Reality shows are as strong as ever, while sitcoms are officially a dying trend. Reality shows sounded the death knell for the sitcom; then another force, YouTube, came along and drove the spike deeper. Michael Hirschorn encapsulated this in an article in the *Atlantic* in November 2006 titled "Thank You, YouTube: DIY Video Is Making Merely Professional Television Seem Stodgy, Slow, and Hopelessly Last Century."

What do reality television and YouTube have that scripted sitcoms don't? Very simple—spontaneity. Or at least the feeling of spontaneity. Even though most reality shows do in fact have a very tight narrative structure, there is still something at the small scale, from one moment to the next, that feels uncontrolled, as if it has the potential to go anywhere.

Sitcoms, on the other hand, are controlled down to the very last detail. If a vase filled with flowers falls over, it's almost certainly because it was written into the script. Each show is broken into clearly delineated acts, with story arcs that follow standard patterns. The net result is an extremely predictable and formulaic style of storytelling. Having a strong, clear structure provides a level of comfort (we always knew Sam and Diane on *Cheers* would resolve their fight by the end of the episode), but eventually the predictability also leads to a loss of energy. The audience slowly absorbs all the major plotlines and standard setup/punch line jokes until the whole genre loses its impact.

Spontaneity is fun, plain and simple. Just take a look at the annual Academy Awards ceremony—the Oscars. What does the public most crave every year? It's not the opening monologue, the dreary montages, the lame jokes from presenters, or the tedious musical numbers. What the audience desperately and eagerly prays for is the *one* spontaneous moment that will live forever. Whether it's Jack Palance dropping to the floor to do one-handed push-ups, Roberto Benigni hopping up on his chair as he calls to the stage, or Sally Field's "You like me, you really like me!"—that's what everyone lives for. It's the spark of magic that comes with spontaneity.

It's the same thing you can routinely see and hear at the Democratic and Republican National Conventions. The television commentators complain, over and over again, about the tightly scripted and controlled nature of the events. Every single moment, every speech, every presentation seems to be so tightly choreographed, down to the last detail. After a while, you get the feeling that the commentators are just hoping that someone, anyone, will trip on their way to the podium, interjecting at least one unpredictable, spontaneous moment.

If you want to see the truly blindingly brilliant charisma of a spontaneous moment, you should watch the original black-and-white film of President John F. Kennedy pinning a medal on astronaut Alan Shepard in the Rose Garden of the White House in 1961. Kennedy accidentally drops the medal, picks it up off the ground, and without missing a beat says, "I give you this medal that comes from the ground up," and the assembled crowd explodes with laughter. The scene has the sort of energy that political convention watchers dream of.

So what is it about spontaneity that is so powerful? It's the element of danger, the idea of performing without a net. These dynamics reach down into the lower organs—down to the gut with a twinge of fear.

And that brings excitement. It also brings an organic element that has a feeling of truthfulness to it. That was what the Meisner acting class was about—making the performance seem real. It's also what improv acting is about: trying to create those electric, totally authentic moments, even at the expense of a lot of rambling, unfocused, less precise moments. Here's how this relates to scientists.

Over the past decade the science community has begun to develop at least some awareness that scientists communicate poorly and need help.

Two major efforts to address this are the Aldo Leopold Leadership Program and the book *A Scientist's Guide to Talking with the Media: Practical Advice from the Union of Concerned Scientists*. Both are important projects, but both have their limitations in that they focus primarily on the first half of communication—substance—but don't yet reach much into the second—style. To explain this further, let me begin at the introductory level.

The Basic Principles of Science Communication

Science, from the beginning of time, has always consisted of two parts. First is the obvious part, the *doing* of science: the collecting of data, the testing of hypotheses, the running of experiments—all the standard stuff.

But there is a second part that isn't so immediately obvious, and that is the *communicating* of science.

Over the ages, *all* scientists, from the highest Nobel laureate to the lowest laboratory technician, have *always* had to take part in both of these activities if they wanted to actually be scientists. Even the technician who sits in the corner of the lab writing down numbers from the DNA sequencer has to, at the end of the day, communicate the data to someone. Without performing both parts (which happens all the time), you have not performed science. You get people who do the science and then fail to communicate it, and you get people who don't do the science but go ahead and communicate (the latter are known as frauds).

There are countless famous stories of great scientists who did a great job of the first part—doing the research—but then totally fell down on the second part. For starters, there's Gregor Mendel, the father of genetics. He is the true icon of poor communication. In fact, someone should create a Gregor Mendel Award for the scientist doing the best research yet failing to communicate it effectively.

Mendel was a humble Austrian monk of the mid- to late nineteenth century. While Charles Darwin was basking in the glow of the celebrity he had gained by communicating directly to the public with his best-selling *Origin* *of Species*, Mendel was toiling away in the Austrian Alps discovering the very genetics that would have given Darwin the mechanism of inheritance he needed to make his theory of evolution complete. But Mendel lacked the sort of self-promotional streak that is essential for scientific success in the United States today. He was a shrinking violet when it came to presenting his foundational work and instead published it in obscure journals, leaving this earth with little fanfare. His most important paper was cited only a handful of times over the next thirty-five years.

It wasn't until several decades later that a number of major evolutionists rediscovered Mendel's experiments and said to themselves, "Holy smokes, this guy worked it all out long ago." The rediscovery of Mendel led to what is known as the "modern synthesis," in which Darwin's ideas on evolution were brought together with Mendel's knowledge of genetics to create a robust theory of how evolution works. Had Mendel been a bit more of a communicator, the modern synthesis might have happened a few decades earlier and science would have advanced more rapidly.

A similar thing happened with Alexander Fleming, who in 1929 discovered penicillin but published his findings in a paper that drew little attention. Instead of going out on the road and communicating his discovery effectively, he left it alone and nothing happened for more than a decade. When Ernst Chain finally discovered his work in 1940 and heard that Fleming was coming to visit, he commented, "Good God, I thought he was dead."

Had Fleming's work been widely disseminated in 1929, it could have led to the development and application of penicillin a decade earlier, saving countless lives. Such are the costs of failed communication.

Effective communication is an essential part of science, for at least two reasons. First, if nobody hears about your work, you might as well have never done it. And second, especially in today's world, if you don't communicate your research effectively, there are many people around who will communicate it for you, and when they do, it will probably be skewed in order to support whatever agenda they have.

The Objective/Subjective Divide

But if communication is so important, why don't scientists put more effort into it?

In my experience, it's because of the objective/subjective divide in science. The doing of science is the objective part. It's what scientists are most comfortable with. A scientist can sit in his or her laboratory all day long, talking to the microscopes and centrifuges, and they will never talk back. I have heard scientist friends of mine over the years rave about how much they enjoy field and laboratory research for exactly this reason—it's all so rational, so logical, so objective, and . . . alas, so nonhuman—a chance to get out in the field, away from people. No politics, no bureaucracy, no administrative duties, just pure rationality.

Unfortunately for them, there is that other part to science called communication, which involves dealing with those often irrational and illogical creatures called humans. And while Mr. Spock of *Star Trek* found humans to be fascinating, most scientists really don't.

In fact, in 1999 I did a video titled *Talking Science: The Elusive Art of the Science Talk*, in which I interviewed a variety of University of Southern California faculty members in the sciences, communication, theater, and cinema. One physicist told me about the whole syndrome in no uncertain terms. He said he had always, all his life, had a hard time speaking to people. So, when he went to graduate school to get his doctorate in physics, it was his

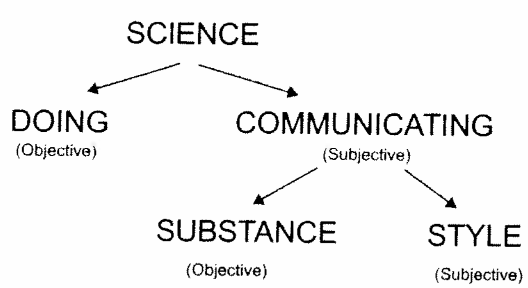

Figure 1-3. The dual nature of science. The objective/subjective divide for both science and the communication of science.

dream come true to be paid to lock himself in a laboratory and not talk to anyone day after day. But then they broke the bad news to him—he would eventually *have* to go to a scientific meeting, stand in front of an audience, and give a public talk about his research. He was furious the day he learned of this, and at first he refused to do it. But it wasn't an option—it was a requirement. So over the years he has reluctantly taken part in the communication of his science, but to this day he says it's the worst part of his career. And I can assure you he is not alone.

Why is science such an antisocial profession? Is it that the profession selects for these traits, or is it that it reinforces these traits? Probably a little of each.

I think my moment of truth on this topic came in my first year as a professor, when I attended a big scientific meeting in San Francisco, scored a poolside hotel suite, and organized a party in my room for the second night of the meeting. I invited about fifty scientist friends from the meeting, but when party time rolled around, about five showed up. All the rest either had evening sessions they wanted to attend or were getting ready for their own talks. I sat in my room that evening, staring out at the pool.

Scientists are wonderful people, but as a group they tend to be a little awkward when they get together. Going to the annual American Geophysical Union meeting just isn't quite the same as attending the Sundance Film Festival.

How can scientists overcome this? My theory is that they need to reach down into the lower organs. I begin by exploring the phenomenon of spontaneity.

How to Find Spontaneity

Not very spontaneous? Feeling like you're that guy who stares at the knocked-over vase and tries to think of what to say? Feeling like Chris Farley interviewing Paul McCartney on *Saturday Night Live*, where he mostly just stares at him and can't think of anything to say other than "That was awesome"? There are ways to work on this problem, one of which is called improvisational acting, or improv.

During my years in Hollywood I had several encounters with improv acting. For starters, I took classes at a couple of the improv programs that are scattered across Hollywood. In particular, I went through several levels of training at Second City, the program that gave rise to John Belushi, Dan Aykroyd, Gilda Radner, and many other great comics.

But more important, early on I became a fan of the legendary Groundlings Improv Comedy Theater, located on Melrose Avenue in Hollywood. The Groundlings is one of the other prime training programs for the major comic actors that emerge on *Saturday Night Live.* It has its own suite of superstar alumni, including Will Ferrell, Chris Kattan, Phil Hartman, Paul Reubens, Jon Lovitz, Kevin Nealon, Maya Rudolph, Kristen Wiig, and many more.

After attending The Groundlings' Friday night shows for years, I finally broke the ice in 2002 by contacting one of the veteran performers, Jeremy Rowley, to see if he might be interested in helping out with my Shifting Baselines Ocean Media Project. I wanted to make a comic television commercial that talked about lowered standards for ocean quality by drawing comparisons to the idea of lowered standards for the arts. For one of the examples I wanted to have a scene of bad dancing. Jeremy had performed an incredibly funny scene in the Friday night show in which he ended up coming out totally naked holding a birthday party hat over his private parts and dancing to a frantic song from the Gipsy Kings. The scene produced screaming laughter from the audience—truly one of the funniest performances I've ever witnessed.

Jeremy helped me with the bad dancing scene, and then we put together a stand-up comedy contest for Shifting Baselines. We then cowrote and directed *Rotten Jellyfish Awards*, featuring Jennifer Coolidge (Stifler's mom in *American Pie*) and Daniele Gaither (of *MADtv*), followed by a series of comic short films using the main cast of The Groundlings. After that, I shot my *Tiny Fish Public Service Announcement*, starring Tim Brennen of The Groundlings and Cedric Yarbrough of Comedy Central's *Reno 911!*, and used a number of Groundlings actors in my feature films. So, over the course of seven years, I spent a considerable amount of time around The Groundlings and absorbed what I could of improv technique.

The most important overall aspect of improv training is that it is based on the idea of affirmation and positivity. (I talk about this in chapter 4, where I discuss the negating aspects of scientists.) But it also draws on spontaneity and the hugely likeable qualities that come with it. The object of improv is to work not from the head but from the gut. To listen very closely and to not wait for your brain to process what you're hearing, but instead to be guided by your instincts. Basically, to *trust* your instincts. To have enough faith in yourself that you don't feel the need to slow things down and think them through, but rather to simply act—impulsively, immediately, spontaneously. It's back to that kid kicking the vase.

Improv actors are like explorers—they open up doors and go inside. They do an improv scene in which someone comes out with something silly and nonsensical, and, instead of the other actors frowning and "negating" it by saying something like "That could never happen," they boldly move forward into uncharted waters.

For example, let's say the actors are pretending to be looking at a llama. One of them says, "Wow, look, it has seven legs." Instead of negating it by saying, "What? A llama could never have seven legs," another actor takes things in a positive, affirming direction by saying something like "Yeah, I wonder what happened to his eighth." And maybe the next one says, "Yes, llamas always conform to the rule of fours—this one must be a rebel." And onward toward increasing silliness, without a doubt, but also occasionally someone might nail a piece of logic. If there had been, for instance, a recent news story about a fast-food establishment having contaminated meat, one of the actors might say, in reference to the missing llama limb, "So that's what was in that fast-food meat." It doesn't all have to be baseless silliness, but it does all have to be affirmative because that helps the idea and the story get larger, and inevitably funnier.

In contrast, the scientist hears the "seven legs" statement and immediately says, "No, that's not possible," and the whole fun exercise crashes to a halt. Yes, this enters into the realm of accuracy, which is part of the scientist's job, but we'll get into that later, in chapter 3. For now, just know that the spark of spontaneity comes from not being careful, and it can be hugely powerful, as I got to see in my work with students.

No Joke: Improv Comedy for Scientists

In the same way that science splits into two parts—the objective (doing it) and the subjective (communicating it)—the communication of science has a divide. Looking back at figure 1-3, you see there is the objective part of communication (the *substance* of what is communicated) and the subjective part of communication (the *style*). Knowing that scientists are drawn to the objective side of science, I think we can easily predict that they are also drawn to the objective side of communicating. And this tends to be much of the focus in workshops that train scientists to communicate better.

The Union of Concerned Scientists' book *A Scientist's Guide to Talking with the Media* asks, in the title of the fourth chapter, "Do you hear what you're saying?" It doesn't ask, "Do you hear *how* you're saying it?" It sticks with the *what*.

That's the difference: what = substance; how = style. Most teachers of science communication are still at square one, working primarily on the substance. And the idea of asking scientists to take lessons in comedy sounds rather absurd. But we've been experimenting with it at Scripps Institution of Oceanography with the graduate students and learning some fascinating things.

Every summer for the past few years I have taught the second half of the communication week in Scripps' orientation course for new graduate students. For the first two days of the week, the course brings in major print journalists from the *New York Times* and the *Los Angeles Times* to talk abc communicating science from their perspective. They tell about how to dc good job when you are being interviewed about your research or scienc related issues.

In the second half we focus on electronic media, including an intensi video-making workshop where the students make their own sixty-secor video. But a couple of years ago I decided to do a little experiment.

Some of the instructors at The Groundlings, including Jeremy Rowle occasionally run corporate training workshops in which they teach imprc exercises to CEOs. They get them to work on lightening up and looking a their communication dynamics from a different perspective. So I manage to talk Jeremy into coming down to Scripps for a morning to do the sam exercises with the students.

He ended up running two hours of improv games, which started ou mostly silly, fun, and of questionable purpose—things like standing in a circle and taking turns saying the letters of the alphabet by having the person tc your right look deep in your eyes and say his letter—"J"—then you turn tc the person on your left, look deep in her eyes, and say, "K," and so on. Really just an icebreaker game.

But, as time went on, the games began to get more complex, and Jeremy ended each game with a detailed explanation of how it related to the students and their highly cerebral world.

The best game of all, and the one that brought the whole purpose home, was called the "add-on story game." Five students stood before the class. Jeremy chose one randomly. She began by making up a story—"Today my car broke down, so I had to take it to the shop." He interrupted her and randomly pointed to another student, who had to pick up where she left off. The next student said, "The mechanic looked under the hood, opened the carburetor, and found a dead bird in it." And then another student was chosen to pick up from there and keep the story going.

And *this* was where we got to see the true mind of the scientist at work. Some of the students kept their minds open, listened closely, followed the story. When called on, they instantly took their best shot at making up something that connected with what was said and kept the story going, even if their contribution sounded silly, like, "The bird woke up and flew out of the shop!"

But others—the more cerebral ones, the thinkers . . . ah, they were the ones who from the very start of the exercise went to work, thinking, "This is a story about a bird in a car motor. I'm eventually going to be called on at random. I don't want to embarrass myself, so I'd better have something prepared for when I get called on." Preparation, preparation, preparation—thinking, thinking, thinking. When they were finally called on, they would say something like "The bird had its wing stuck in the carburetor and couldn't get loose," even though the previous student (to whom they failed to listen) had just said the bird flew away.

And all of a sudden the story would stop dead.

The net result was very clear as the smiles vanished from everyone's faces and some of the students would say, "Oh, boo! No, that doesn't make any sense."

Jeremy would then stop the exercise and explain what had just happened. He would point out that the purpose of improv is, first, to listen very closely and, second, to trust yourself—to know that even if your mind is blank at the moment, you'll figure out something, even if it's as pointless as kicking the vase as the young student had done. And, finally, to do all that you can to make your partner—the person who came before you—look as good as possible. Suddenly taking the story back to having the bird stuck under the hood makes the previous person look bad, as if he had been wrong in telling about the bird flying away.

You can see how this relates to being interviewed. In the one form of science communication training, you are told to arm yourself with a stack of sound bites, metaphors, analogies, and message points. Then, regardless of what the interviewer is asking, you are to push your own agenda and get *your* message out.

This orientation leaves the scientist thinking, "Me, me, me—I need to make myself look good." Which seems logical. But consider this—what if there is actually something unique to be gained by taking the opposite approach—by thinking, "Him, him, him—I need to make the interviewer look good"? Yes, it's counterintuitive. And so are a lot of things when it comes to communication, since it's not always entirely rational. Sometimes you need to be a little less direct and literal minded (the subject of the next chapter).

With the improv approach, you try to make the interviewer look good. There is an upside and a potential downside. The upside is that you will have better chemistry in the interview, be more relaxed, a more enjoyable person. The downside is that you might not manage to "get in" everything you wanted to say or make certain everything is completely accurate.

Which is better? It's a question of substance or style. The former is better if you're in a setting where everyone is likely to hear and care about everything you have to say. But, if you're in a highly superficial medium like television, which is meant not for the academic audience but for the general public, and where people pick up much more on what they're seeing than on what they're hearing . . . then it's quite possible the improv approach will be more effective. It can result in the viewer saying, "I really liked that person who talked about global warming—she seemed really comfortable, knowledgeable, and . . . I didn't understand what she had to say, but just the fact that she seemed worried about global warming makes me think it's a serious issue."

That's in contrast to the scientist who spends the entire interview correcting the interviewer (i.e., negating), forcing the issues by giving answers that have nothing to do with the questions asked, and who seems to be pushing a story that the interviewer isn't asking for—something that happens every day on news shows.

For improv in general, the basic idea is saying, "Yes, and . . ." to everything that comes up.

Your partner says, "Look, there's Sasquatch, out in our front yard." You answer, "Yes, and . . . he looks really angry." Your partner says, "Yes, and . . . he just tossed your car over the house." And you say, "Yes, and . . ."

You just keep adding to the story, making it bigger and more interesting. You never halt the flow with anything negating—like "Sasquatch could never pick up a car."

It's a different way to communicate. It's not as precise as a scientist would like. But it is more likeable.

More from the Gut: Intuition

And now it's back to the battle-ax acting teacher. It's time for another one of her basic principles. This one is very powerful and leads us to the thing known as intuition. The concept is "Great actors memorize the script, then forget it." (Always made me think of those old denture ads, "Fixodent and forget it!")

That principle was repeated night after night, and it became very important to me years later. What it means is that, in the early stages, the actor ends up very much "in" his or her head, having just freshly memorized the lines. But with repeated rehearsal, the material gets committed at a deeper and deeper level—as if it drifts downward from the brain and into the lower organs. And as it does, the actor is able to add sincerity to the material as it moves down to the heart, then have fun with it and add more humor as it gets into the gut, and finally add genuine sex appeal when it reaches the lower organs.

But something extra happens when the actor "forgets" the script. After weeks of rehearsal, the actor goes away for a few days and doesn't think about the material. Upon return, the performance is no longer coming from the head. The actor is no longer standing in the room trying to picture the lines on the pages of the script. Instead, he is standing in the room, looking at the man pointing the gun. When he speaks, it comes not from memory but from what is seen and felt at the moment. It is alive and real. And—guess what—when he says, "Don't shoot me! I've got three kids," without ever thinking about it, his words turn out to be very close, if not identical, to what the script said. When he "reaches" for the line, what he gets is what was in the script—available to him because the script was absorbed down at the level of intuition.

On a similar note, years ago I saw an interview with a British actor who was asked why his countrymen perform Shakespeare so much better than Americans. He said it's because British actors go beyond intellectual respect for Shakespeare. They are raised with the Bard from a very early age. By the time they are adults, they have committed the material to such a deep level that they are able to add all the elements of the lower organs to it—passion, humor, and even sex appeal. In contrast, American actors tend to learn Shakespeare later in life, treat it with overwhelming reverence and dignity, and end up "caught up in their heads"—still thinking, "Oh, my goodness, I'm doing Shakespeare; I'd better do it right."

Reaching into the lower organs is the ultimate goal of the Meisner technique, and it's what produces the wonderful, incredibly likeable chemistry that is the essence of good acting. This is what overly cerebral scientists lack—but it's an important part of interacting with the public. And it was a rule I tried to follow in making *Flock of Dodos*.

Dodo Intuition

In the spring of 2005, after running the Shifting Baselines Ocean Media Project for three years, I read about the conflict over the teaching of evolution versus intelligent design in Kansas and immediately decided I wanted to make a documentary about it. More important, I also decided to put to work all I had learned in my Hollywood education. Instead of studying the subject for the next six months, figuring out exactly what I wanted to say, and then writing a script, I wanted to rely on my instincts and get to work quickly.

Within two weeks of reading H. Allen Orr's article "Devolution: Why Intelligent Design Isn't" in the *New Yorker*, I was in Kansas with a film crew conducting the week of interviews that provided the core of the movie. Instead of carefully preparing for each interview, I opted to trust my instincts, trust my twenty years of studying evolutionary biology, trust my knowledge of editing (for ensuring accuracy down the line), and focus on doing a good job as an actor in each interview. I felt as if I had memorized "the script" over the past two decades. The best thing I could do now would be to forget it.

The result was that I didn't cover all sorts of important topics and questions that I probably should have in each interview. But the trade-off was that I was doing my best to listen to the person and respond, with as little thinking as possible, in an effort to generate good conversation.

This is an element of style that's difficult to teach in workshops and can be elusive to scientists who feel they owe their first allegiance to accuracy and the facts.

But there's more to life than just accuracy. Yes, that's a very touchy subject for scientists. Some might even disagree with that statement—saying that accuracy is *all* that's important. Suffice it to say, the topic is a major can of worms, which I will delve into in considerable detail in chapter 3. (Stay tuned!)

But for now, before moving on to the chapter's final topic—not being so cerebral—let me go back to that improv acting exercise at Scripps. It was such a fascinating contrast with everything the print journalists had taught in the first half of the week, and the students said so.

What the print journalists were teaching was substance—get all your facts organized, shrink them down to sound bites, figure out your message, go into any interview with a clear agenda of what you want to convey, and then make sure you are in charge. In fact, the Union of Concerned Scientists produced a PowerPoint presentation to go with its book on how scientists should deal with the media. It offers the following nine tips on preparing for an interview:

1. Do your homework. Before every interview, ask the reporter what the topic of the story is, where it will appear, and when and where the interview will take place.
2. Interview when you're ready. Even if the reporter is on a deadline, ask if you can talk in ten minutes so you can prepare your main messages and sound bites.
3. Repeat, repeat, repeat. Unless you are on live radio or television, every interview is edited. Take control of how you are edited by driving home your main points.
4. If you stray off course, bridge back to your main message.
5. End the interview on your terms.
6. Never speak off the record.
7. Never guess.
8. Emphasize qualifications (meaning if you have to make a point that has limitations to it).
9. Never get angry.

Let's take a look at these pointers and consider what sort of advice it is the authors are giving. If there's one basic principle they are espousing, it's that the scientist should control, control, control the interview. The first point says to *assert* yourself by insisting on knowing all the details. The second point says to *assert* yourself by not letting the interviewer start before you're ready. The third point says to *assert* yourself by making the same points, over and over again. The fourth point says to *assert* yourself by bridging back to your main message. The fifth point says to . . . well, you get the idea.

It's nice that they're trying to instill self-confidence in scientists when dealing with the media, but take a look at it from the other side. If you were a journalist, would you want to be given a bunch of orders from the scientist you're trying to interview? "I'm not ready to start the interview. Let me make this point again. I want to say this again. Let me get back to my main message."

Finally, there is a danger to being overly prepared for an interview. A major television news reporter told me recently about an interview he did with a woman who is a top climate scientist. She showed up so heavily prepped, with her head so full of sound bites and analogies and catchphrases, that halfway into the interview she seemed to lock up—having a hard time connecting to his questions, giving answers that were so full of her message that they hardly related to what he was asking, causing him to have to ask questions a second time. She finally called the interview off, with much apology, saying it just didn't feel right.

The reporter told me he ended up so frustrated, wishing that she, and many other scientists he interviews, would just relax, trust him, and let him guide the interview instead of turning it into a struggle.

This is the divide between the heavy preparation and showing up with an agenda versus the improv style of trusting yourself. The former guarantees accuracy, and the latter leads to a much greater chance of hitting that one golden moment when interviewer and interviewee connect—the moment that later, in postproduction, causes the editor to turn around in his chair and say, "Hey, everybody, come take a look at this."

Take your pick which you'd rather have. Given that for television your one-hour interview will probably get cut down to thirty seconds, you begin to see the value of scoring that one great moment versus a solid hour of boring (but accurate) details.

Intuition

At the start of the chapter I mentioned the Myers-Briggs Type Indicator test. It is built around four "dichotomies," one of which is the divide between sensing and intuition. What this means is the split between people who want to base their decisions on information that is touchable, hearable, seeable, and present in the here and now, and others who are open to less tangible, more abstract information that could even be from the past or the future.

In essence, it's the same "head versus lower organs" divide I've been talking about. So if the highly logical and analytical processes reside in the brain, what do we find at the other end of the spectrum?

Well, if we go way down to the far other end of the spectrum, we end up in the land of sex, and all hell breaks loose. This was Freud's undoing—trying to apply rationality to this realm. Good luck. He ended up with a career that was a mixed bag, which is why many scientists still despise him for coming up with nonscientific ideas—ideas that couldn't be tested or "falsified."

Basically, woe unto him or her who honestly thinks it possible to create rational and consistent theories of sexual forces. It's sort of like the observer effect, where you can never be certain whether what you're observing is the real state of nature or the state of nature that has been altered by your observing it. Same for sex. Those studying it have to deal with their own sex drives, which will probably drive them crazy.

Makes me crazy just to think about it. So let's stay away from this region. Use it at your own peril. Start off a speech with a sex joke at your own risk. Make a music video about the prodigious penis of the barnacle (barnacles have the longest penis relative to body size) and watch all sorts of weird things happen when you show it to groups of scientists (one male scientist accused me of being homophobic—how does that work?).

But there's another force, just above the belt, that is very important to science and scientists—intuition.

What is intuition? Start searching it on the Internet and you'll quickly find your way into wacky, far-out definitions like "the holistic merging of the cognitive senses," "the noncognitive experiences and memories," and "the body's bioelectrical sensitivities." Um, yeah. Right, dude.

Let's just say, in simpler terms, intuition is the act of knowing or sensing without the use of rational processes. Again, pretty much the opposite of what goes on in the brain.

Intuition is very important to the world of science because so much great science begins with it. There are countless famous examples. Descartes supposedly thought up the idea of Cartesian coordinates by lying on his back while sick, watching spiders spin their webs on the ceiling. Newton saw an apple fall from a tree. Kekulé dreamed of a snake biting its tail and came up with the circular molecular structure of the benzene ring.

These are all great discoveries that began as something that didn't look like science at all and lacked any data or rational thought. It's as if the gut is a great starting point for invention, innovation, or discovery. But once the idea begins to crystallize, it then must be transported northward to the brain so it can be subjected to the process of science.

James Watson described this interplay between intuition and science wonderfully in *The Double Helix*. In 1953 he and Francis Crick were getting close to discovering the structure of DNA and racing against a number

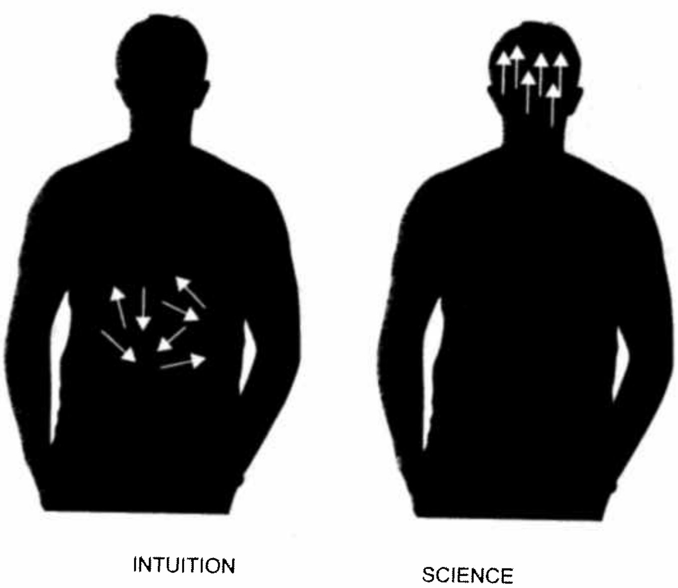

Figure 1-4. *Left*, intuition: when Watson and Crick knew Pauling's structure was wrong. *Right*, science: when Watson and Crick had figured out how Pauling's structure was wrong.

of other scientists. Suddenly Linus Pauling at the California Institute of Technology beat them to the punch and published a paper with his version of the structure. They were stunned to hear the news, but Watson says that the moment he and Crick looked at Pauling's paper they knew he had it wrong. They couldn't tell you exactly how or why in that first instant, but their intuition made them feel certain they were right. It would take them several weeks in the laboratory to move their intuition up to their brains, formulate a solid explanation of why Pauling was wrong, and eventually come up with the correct structure of DNA, which is what won them the Nobel Prize.

For a much more detailed examination of intuition and its basic properties in the real world, read Malcolm Gladwell's book *Blink*. He talks about art forgery detectives who can spot a forgery almost immediately, but try to get them to explain why they know it's a forgery and you'll probably hear them offer up a lot of contradictory thoughts until they've had a chance to really analyze the artwork, move the process to their brain, and smooth out the logic and thoughts.

Intuition is not science, yet it is a very important and powerful precursor to science. More science programs should spend time getting students to understand and appreciate the difference. One thing I tried to do with *Flock of Dodos* was show the relevance of this term to the issue of intelligent design. The science world did a good job of spewing all its bile and anger at the intelligent design movement in making it clear that intelligent design is not science, but what few, if any, bothered to do was go further and answer for the general public the question "Well, if it's not science, then what is it?"

The answer is intuition. It is a hunch—a gut instinct that much of what exists for biological diversity has been created not by nature but by a divine being, the designer. This, to many, is a beautiful and inspiring idea, but in the end that's all it is—an idea—a piece of intuition. And intuition is not science.

Onward . . .

So now we have reviewed what I think is the most important dynamic in all of communication—the role of the four organs. And while we can plainly see that the brain is the epicenter for all that's permanent and lasting when it comes to information, I hope that you also now have an idea of what the lower organs can offer. They provide extra vitality, sparks of energy, an organic element—in general, they create the essence of what is meant by the word "human."

The tendency to be "too cerebral" leads to a preference to think rather than act (as in "doing something"). If you can manage to get past this and begin doing things, the next challenge is to find the creative energy to do the most effective things rather than just the most obvious. This requires that you not get too carried away with being literal minded, as I will explore in the next chapter.

doctors in the cafeteria wanted to see Young Dr. Hollywood. And that was what they saw." People like their big stories. It's a natural part of being human.

Accuracy versus Boredom: The Two Mistakes of Storytelling

So now we know that scientists can be very, very good at maintaining their sobriety and making sure that, whether or not they enjoy the story being told, they don't get so swept up in the magic that they allow the storyteller to make big mistakes. But is accuracy the only important challenge a storyteller faces?

The answer is, of course, no. A storyteller faces two big challenges: to keep it accurate *and* to keep it interesting. If either is not attended to, errors will result. We'll call these two errors "type one" and "type two," in part because I want to eventually draw a parallel with the world of statistics.

To a scientist, there is nothing worse than inaccuracy. The *American College Dictionary* defines science as "a branch of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operation of general laws." The key part is "facts or truths." Science means nothing if it isn't grounded in the truth. This is why scientific fraud is held up as unforgivable. It seems people can commit plagiarism in other disciplines and get a slap on the wrist, but in science, to be caught fabricating data is to have lost all meaning to the profession and to be banished for the rest of time.

As a result, scientists watch movies about science with an eagle eye for every single detail. And the makers of films about science live in dreadful fear of hearing from scientists that they "didn't get it right." When you hear scientists complaining about Hollywood's portrayal of them, the complaints are always along the lines of "That's inaccurate—that's not what we really do or sound like." What you don't hear much complaint about is the second fundamental error—mistakes of boredom.

What is boredom? It's the state of being bored. What is the state of being bored? It is to experience something that is dull, tedious, repetitious, uninteresting. So it's the opposite of interesting. And to "be interesting" is, according to the closest dictionary I can find . . . "to arouse a feeling of interest."

There's that word again, "arouse." It's about stimulation. Something that is interesting stimulates the neurons in the brain. Something that's boring doesn't. And when the brain is numbed into disinterest, communication doesn't take place.

So what's worse, to communicate inaccurately or not to communicate at all?

It's the dilemma that scientists and science communicators face every single day with every communication exercise they attempt. And that is because accuracy and interest do not always go easily hand in hand.

Let's get back to those two errors that I mentioned in terms of telling a story. They are similar in nature to the two main errors that statisticians worry about in their work.

When scientists need to make a decision ("On the average, is this species of tree bigger than that one?"), they bring in the statisticians. These are the folks who enable us to say confidently, on the basis of numbers, whether the decision is "Yes, this one is bigger" or "No, this one is not bigger."

With any given decision like this, two fundamental errors can be made. The first error possible, known generally as a type one error, refers to the idea of making a "false positive." In a legal case, it would be basically the risk of hanging an innocent man. In the case of scientifically describing nature, it would be the risk of saying you see something when in reality it isn't there.

The second error possible, obviously known as a type two error, refers to the idea of making a "false negative." In a legal case, it would be the risk of letting a guilty criminal go free. In the case of nature, it would be the risk of failing to see something that exists. For example, the two tree species really are different in size, but you don't have enough data to draw that conclusion, and thus you make the mistake of concluding that they are not different in size.

The most important thing to note for these two errors is that we don't live in a perfect world. Which means that it is rarely possible to do a good enough job that you can guarantee not making either mistake. To deal with this, we end up choosing one of them as being more important than the other. In the case of the legal system in the United States, we place highest priority on the type one error. We say that, all else equal, we're more concerned about punishing innocent people than we are about letting guilty people go free. And so we have a default rule that a suspect is innocent until proven guilty. A nation could just as easily have the opposite legal system—that those arrested are assumed guilty until they can prove otherwise. The key point is that you have to choose one. It's like in baseball, where "a tie goes to the runner." It has to go one way or the other.

So here's where it gets interesting for communication. We see the same two types of errors for storytelling (errors of accuracy versus boredom). The choice must be made which of the two errors is most important. Yes, I know, you're thinking, "I want both—a story that's accurate *and* interesting." That's ideal, but in the real world you still have to choose one, just as you do with the two errors in statistics.

And when the dust settles, it's clear that scientists, being detail oriented and believing that accuracy is sacrosanct, will always focus on errors of accuracy as their greatest concern. In the same way a physician lives by the credo of "First do no harm," a scientist lives by "First, make no mistakes of accuracy." And this is a great strategy for the ivory tower, where the rules for decision making are yes, no, and later. But, as the amount of information and the pace at which it is communicated increase in our society, "later" is becoming less of an option for the science world. And that leads to a major, major, major quandary, which I shall now address through an extremely important case study.

Case Study: Two Global Warming Movies of 2006

Before I begin this discussion, I want to make my overall opinion clear concerning Al Gore's movie *An Inconvenient Truth*. It is, plainly and simply, the most important and best-made piece of environmental media in history. End of story.

You can talk about Rachel Carson's *Silent Spring* and how it gave birth to the entire environmental movement, but Al Gore's movie took the broadest and most urgent environmental issue and jumped it up from background noise to buzzword. There's no point talking about any shortcomings as if they mattered. You can expect only so much from a single piece of media. His movie went way beyond what anyone could have realistically expected. In the spring of 2006, when I was at the Tribeca Film Festival with *Flock of Dodos*, I heard skeptics in the independent film world laughing about Al's movie being "a PowerPoint talk—who's gonna want to buy a ticket to a movie theater to see that?" Most of them couldn't believe it when the movie scored over $50 million in worldwide box office. It was an unmitigated success that deserved to win both an Academy Award and a Nobel Prize, and, guess what, it did. Total success.

However. That said, it doesn't hurt for us to take a few minutes to compare it with another movie on the same subject that came out the same year from the same executive producer.

In April 2006, HBO aired a documentary about global warming titled *Too Hot Not to Handle*. It is a very solid, relatively impersonal and objective effort featuring interviews with a lot of top scientists. It aired on Earth Day and came out on DVD a few months later.

In May 2006, the feature documentary *An Inconvenient Truth* premiered. The movie is a personal narrative by former vice president and Democratic presidential nominee Al Gore about his lifelong connection to the topic of global warming, dating back to his undergraduate days. Interwoven with his PowerPoint presentation of the impending risks of global warming are personal insights, in which Gore reveals the pain of tragedies involving his sister and his son, as well as occasional humorous quips.

Here's where it gets interesting. In addition to their subject matter, these two movies have one large element in common—the executive producer, Laurie David, was a major mastermind of both movies. She's the former wife of comic writer and actor Larry David—cocreator of *Seinfeld* and star of the extremely funny HBO series *Curb Your Enthusiasm*.

Laurie David is herself a force of nature. She has been a board member and trustee of the Natural Resources Defense Council for years and has collected mountains of accolades for her relentless work on global warming. So it is fascinating to compare these two films, not just in terms of substance and style but also in terms of our two potential errors—accuracy and boredom.

The HBO film has tons of substance. It is packed full of scientists talking, and when experts of their caliber talk, they are incredibly accurate. They know their stuff. So it scores an A+ on substance, and you can be certain the accuracy is high. In terms of style, it was well shot and well produced, with plenty of beautiful images of nature to illustrate what the scientists are talking about. But when you consider the question of whether it's boring—well, it doesn't have a personality associated with it. It doesn't tell any sort of intriguing story. It mostly just disgorges the facts and details and lets them splat on the floor for everyone to pick among. Bottom line, it is pretty boring.

The Al Gore movie is sleek, cool, and as hip as the formerly dull vice president could possibly be packaged. It scores pretty close to an A for style. And when it comes to substance, it has plenty. That's why it won an Oscar—it's rich in both substance and style.

Gore didn't shy away from wading into one graph after another, in a manner no one has ever had the courage to do when hoping to reach the general public through film. So it is a reasonably unboring movie (though I'm sure thousands of schoolkids who have been forced to watch it would disagree). But when it comes to accuracy . . . *that* is where it gets interesting.

The Al Gore film is not 100 percent accurate. Countless opponents of global warming science have made as much hay as they possibly could out of this. But both sides agree there are shortcomings in accuracy.

Perhaps the most reliable assessment comes from Danish biologist Kåre Fog on a Web page comparing the number of "flaws" and "errors" in the Gore movie with those in the books written by Bjørn Lomborg, one of the most prominent in the chorus of voices who are skeptical of environmentalism. It's a fairly balanced assessment that, if anything, is probably skewed in Gore's favor, since the site is so anti-Lomborg. But even Fog's analysis concludes that there are at least two "errors" (things that are factually incorrect) and twelve "flaws" (he defines a flaw as "a misleading statement which does not agree with the facts").

The *New York Times* gave an overview of the science community's assessment of Gore's film. Perhaps the most important opinion in the article is that of James Hansen, director of NASA's Goddard Institute for Space Studies and the leading critic of the George W. Bush administration's handling of global warming. The article says, "Hansen said, 'Al does an exceptionally good job of seeing the forest for the trees,' adding that Mr. Gore often did so 'better than scientists.' Still, Dr. Hansen said, the former vice president's work may hold 'imperfections' and 'technical flaws.'"

When those words come from such a powerful scientific source, who is desperately fighting the fight for global warming concern, you know there genuinely are "errors of accuracy" in the movie.

And yet, when we look at a few simple indicators of the "success" of the two films, what do we see? As I write this, looking at Amazon's DVD sales, the HBO movie is ranked just over 35,000, while the Al Gore movie ranks 431. And when I look at their respective pages on the Internet Movie Database (www.IMDb.com), I see that the HBO movie lists just 2 external reviews, while the Al Gore movie has 357.

Guess which movie had the greater impact? Try asking your neighbors which title they recognize. One of the two reviews listed for the HBO movie

Table 3-1. *Too Hot Not to Handle* versus *An Inconvenient Truth*

	Too Hot Not to Handle	*An Inconvenient Truth*
Amazon rank	35,000	431
IMDb external reviews	2	357

actually compared the two movies, side by side, and had this to say, referring to Davis Guggenheim, director of the Al Gore movie:

> While Guggenheim's film is split more evenly between biography and science, and *Too Hot Not To Handle* is more heavily weighted towards the facts and figures, it's not the most compelling presentation. It's the cinematic equivalent of brussel sprouts vs. chocolate: one is good for you and certainly something of which everyone should partake, but the other is definitely tastier and more appealing.

Now, here's the most important detail of all. I spoke with one of the scientists in the HBO movie. This scientist told me that when it came to that movie, Laurie David did a very conscientious job of getting everything right scientifically, at great cost in time, energy, and entertainment value (as the review above indicates).

But when it came time for the Al Gore movie, "she basically asked all the scientists to leave the room," this scientist told me. She simply said that global warming is too important a topic to allow it to get bogged down in facts, details, minutiae, excessive attention to detail, and poor storytelling.

They went for it on the Al Gore movie. They made a film that scored over $50 million in box office worldwide, that was not totally accurate yet is still endorsed by James Hansen and most every other major climate scientist, and, most important, that changed the world. What do you say to that?

The *New York Times*' final word on the subject:

> "On balance, [Al Gore] did quite well—a credible and entertaining job on a difficult subject," Dr. Oppenheimer said. "For that, he deserves a lot of credit.

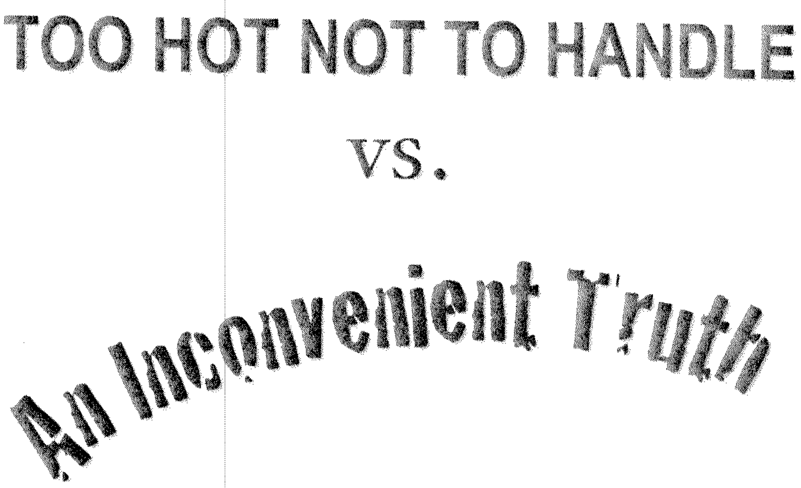

Figure 3-4. What did *Too Hot Not to Handle* and *An Inconvenient Truth* have in common? They had the same executive producer, Laurie David. *Too Hot Not to Handle* was accurate but not popular. *An Inconvenient Truth* was popular but not accurate. Guess which one was full of scientists.

If you rake him over the coals, you're going to find people who disagree. But in terms of the big picture, he got it right."

You Choose: Accurate but Not Popular, or Popular but Not Accurate

I will never, ever endorse the idea of striving for anything less than 100 percent accuracy in the making of any film related to real issues in the world of science. My movie *Flock of Dodos* has no scientific "errors" in it. But it also has very little science content, particularly in comparison with something as bold as Al Gore's film.

Nevertheless, this is the fundamental dilemma facing the world of science today. What are you going to do about this movie that turned out to be the most important piece of environmental media in history yet is not completely accurate?

The major scientists agree that the movie's errors are minor and do not change its overall message, which they feel is completely accurate. But still, if you wrote a scientific paper and it was revealed that your data points in a graph were fudged even just a little bit to make your graph appear more convincing, you could say "Bye-bye, tenured professorship."

There's a fundamental disconnect here, and given the idealized, objectivist, rational-thinking values that true scientists cling to, I don't think they ever want to have to deal with this dilemma. But it's there, it's real, and it's as fundamental to the communication of science as the bonds that hold molecules together.

So the big question remains: What are you gonna do when you finally realize there is more than accuracy involved in the effective mass communication of science?

Go ahead, tawlk amongst yerselves on that one.

One More Handicap for Scientist Storytellers

Here's a quick story about coupons. Once upon a time, when I was in high school, my father sat down at the breakfast table, opened a new box of Wheaties cereal, and began pouring the contents in his bowl, but all that came out were paper coupons. He was late for work anyhow, so he got up, disgusted, threw the box on the table, muttered something about "stupid products," and stormed out.

My mother and brother stared at the box for a moment and then closed in. There was no cereal in it. Something had gone wrong on the production line. The only thing it had was about 1,500 coupons. Each one was worth one point, and you had to collect 100 to win a free turkey. Thanks to some freak accident, we had enough for fifteen free turkeys! (I swear to this; you can ask my mother or brother.)

We cashed some of them in at our local store, kept a few, and gave a few to friends and the rest to our church. My father never really quite got it. I don't think he ever made it past his anger about the absence of his cereal. But this tale bears relevance to science communication and storytelling.

My father was as mad at his box of Wheaties as a lot of today's scientists are at the attacks on science. And yet, just as my father stormed away from a potential opportunity, it is the same story when scientists try to shut down the attackers of science. They are missing a valuable communication opportunity—a chance to tell a good story.

The Heart of a Story Is the Source of Tension or Conflict

One of the simplest rules they drilled into our heads in film school is that "the heart of a good story is the source of tension or conflict." Read any standard book on screenwriting: this is what it will tell you. And this is the major source of problems for most boring movies—no significant source of tension or conflict.

Do you think those science "educational" films I got subjected to in junior high school told stories? Of course not. They were just facts, facts, facts. No conflict. Nothing at stake over how it will turn out. It was like watching paint dry. You're not worrying about whether it will dry—you pretty much know it will. There's just no story to hold your interest.

A good story begins at the end of the first act. That is where the tension is established. For the first part of a movie, we usually get to know some sort of place and people. Everyone's happy. Right about the point where you start to think, "Something had better happen or I'm changing the channel," something usually does happen—the monster comes to town, the husband cheats, the child is kidnapped. Basically, the audience members sit up in their seats and say, "Whoa, this looks like a good story."

Here again is where overly literal-minded scientists go wrong. They look at the people attacking evolution or global warming science and they get furious, wanting to shut them down and prevent the public from hearing them. But all you have to do is look at the number of times the subject of evolution has appeared on the cover of *Time* and *Newsweek* magazines in the past five years. It was hardly ever on the cover during the previous decades, but suddenly the conflict brought about by the intelligent design movement turned the subject into a good story, making it of interest to a broader audience.

The attackers of science are a potential communication opportunity. They are a source of tension and conflict. They can actually be used to tell a more interesting story, one that can grab the interest of a much wider audience. Which is exactly why I've used them in both of my movies.

Concision and the Elevator Pitch

So, now that I've overstayed my welcome with this chapter, I will finish with a few words about keeping things short. In the excellent 1992 documentary *Manufacturing Consent: Noam Chomsky and the Media*, the legendary linguist and political activist Noam Chomsky complains about his battles with the medium of television, specifically the news talk shows that won't have him as a guest.

Over the years, Chomsky has learned about a criterion that television producers call "concision": the ability to speak in concise sound bites and not go on and on and on, like I did with Spike Lee once upon a time. Chomsky views it as a conspiracy—television producers end up using that criterion to decide whether they want you as a guest—not whether you're the world's top expert on the topic they are covering but whether you are able to shut up when needed. Chomsky does not accept this idea of keeping things brief, and in the movie he seems proud of and rebellious about it.

Well, what he calls a conspiracy, I call just plain common sense. It is a basic conversational skill to be able to listen while talking so you can recognize when you're boring your audience. A lot of intellectuals, once again preconditioned from too many years of lecturing to prearoused students, have lost this ability to self-edit. Judging from Chomsky's comments in the documentary, he is one of the worst.

And this brings us to the idea of the "elevator pitch": the ability to explain your project, whatever it is, so succinctly that you could get all the way through it in a single elevator ride. How do you do this most effectively? By having a clear structure to your information, using the basic three acts I've talked about.

You set up your subject (first act), give it the twist at the end of the first act (first plot point), explore several possible ways to untwist it and relieve the tension (second act), reveal a possible solution (second plot point), and then weave all the content together to release the source of tension (third act).

Something like this: "I study a starfish on the California coast—the only species that spawns in the dead of winter. I thought it might be due to predators of the eggs being less common at that time of year, then I thought it was due to the best timing for the spring algae bloom, but now it looks like it probably has something to do with a seasonal migration of the starfish, which is what I now study—the way that spawning season might be related to adult movements of starfish."

"Starfish on the California coast" is the first-act setup. "The only species" is the establishment of tension (sets up the question "Why is it different?"). "Predators" and "algae bloom" are the multiple themes of the second act. "Seasonal migration" is the relief of tension, and "what I now study" is the third-act wrap-up.

And there's the shorter version, for the single-floor elevator ride, which is only a single line—"I study the one species of starfish that spawns in the dead of winter instead of during the vibrant spring season." That's enough to establish the sort of tension ("Why is this starfish different?") that will leave the listener still thinking and interested when you step out of the elevator on your floor.

This shorter version is the same as what is called "high concept" in Hollywood, the telling of an entire story in a single sentence or phrase. I'm sure you've heard the ultimate example of this—"snakes on a plane," which actually ended up being the title of a mediocre 2006 movie. It's usually the mixing of two simple elements, each of which tells its own story—"snakes" signifies a dangerous thing that you'd better not let loose, "a plane" signifies a confined space in which you wouldn't want something dangerous loose. The combination instantly fires up your imagination, which is the goal of a good story.

For the elevator pitch, "spawning starfish" signifies something that needs to happen when things are alive and conducive to the survival of the spawn, and "dead of winter" signifies the worst time of the year.

Concision versus "Dumbing Down"

One of the criticisms of *Flock of Dodos* (as I've mentioned, there were many—particularly from the science bloggers) was that I was advocating the "dumbing down" of science. But I was actually trying to do just the opposite.

Let's look at the difference in these two terms. "Dumbing down" refers to the assumption that your audience is too stupid to understand your topic. So you water down all the information or just remove it, producing a vacuous and uninteresting version of what in reality is complex and fascinating. "Concision" is completely different. It means conveying a great deal of information using the fewest possible steps or words or images or whatever the mode of communication is. The former results in a dull, shallow presentation; the latter is a thing of beauty that can project infinite complexity.

Just ask a mathematician about concision. It's the difference between the clumsy mathematician who needs 100 steps to solve an equation and the skilled one who can do it in 5 simple steps. The latter is arrived at either by genius or by hard work. And that's all I'm advocating for science communication—that you be either a genius or a hard worker. That you accept that poor communicators are able to say the same basic things as good communicators—they just need a lot more time and space in which to do it, which ends up boring everyone.

Neil deGrasse Tyson and a Well-Told Story about *Titanic*

So let me tie this chapter up into a neat little package by showing (rather than telling) the real-world power of a well-told story.

Astronomer Neil deGrasse Tyson is the sort of natural born storyteller that the science world desperately needs. I attended a Hollywood event where he spoke and showed what I mean. The event was put on by the National Academy of Sciences as part of its new Science and Entertainment Exchange program, which is an effort to help improve the accuracy of science in movies and television.

Tyson talked about the movie *Titanic*. At the end, when the ship has sunk and everyone is floating in the North Atlantic Ocean, you can see the stars in the night sky above them. But when he first saw the movie in a theater, Tyson noticed something very troubling. As he explains it, there are only two sets of stars the moviemakers could have put up in the sky—the right ones (the Northern Hemisphere constellations) or the wrong ones (the Southern Hemisphere constellations)—so they had a fifty-fifty shot of getting it right. Guess which one they chose.

He said it spoiled the movie for him (typical scientist!), but a couple years later he was walking down the street in New York City and happened to randomly spot the director of the movie, James Cameron. He introduced himself and politely told him of the mistake. He said that Cameron took it in for a second, thought it through, and then sarcastically said, "Gee, I bet if we hadn't made that mistake the movie would have made a couple hundred million more at the box office."

But there's more to the story. Tyson said that in 2005 he got a call. It was one of Cameron's producers, who said they were re-editing the movie for the ten-year anniversary DVD edition, and "Mr. Cameron said you have some suggestions for us about our stars."

Now, that is a good story. Three months later, I told it at the beginning of a workshop on storytelling. Two days after that, at the end of the workshop, without forewarning and after subjecting the students to a two-day "information storm" of lectures and discussions on a wide variety of subjects, I closed the workshop by asking if anyone could remember anything at all about Tyson's "*Titanic* story." What they said surprised even me. A woman recounted the story with complete precision. And most everyone else in the class, while impressed with her performance, said they could probably have done just about as good of a job. Bottom line: it made them believers in the power of a well-told story.

Tyson's story is so effective in part because it has the basic elements of three-act structure. It has a beginning that sets up the theme (inaccuracy of science in big-budget movies), it has a middle that takes us to the opposite place from where we were hoping to go to (the hopelessness of it all when Cameron ridicules the inaccuracy), and an ending that is truly uplifting and satisfying (the sign of hope for humanity when it turns out Cameron was in fact troubled by the inaccuracy).

That is the power of storytelling laid bare. If you can encapsulate your message to the general public in a story as amusing, as compelling (with clearly dramatic highs and lows), and as concise as that, you could . . . well, for starters you could maybe end up as popular and effective a science communicator as Neil deGrasse Tyson!

Being able to tell a concise, interesting, and entertaining story that also conveys substance is a trait that everybody likes. And that brings us to our next chapter, on the importance of creating a likeable voice—the last of my admonitions about being "such" a scientist.