DESIGNING A FRESHMEN SEMINAR ON THE SOCIAL PSYCHOLOGY OF SCIENCE

An Interactive Qualifying Project Report
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by

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1. DNA Discovery case
2. Psycho-Sociology
3. Potential Freshmen Seminar

Abstract

This project offers a possible model for a freshmen seminar. It re-evaluates the current STS-1207 course, Introduction to the Psycho-Sociology of Science, and builds upon studies of cognitive and personality styles to introduce the politics and social workings of science. The project discusses how the course would be suitable for a freshmen seminar because the in-depth study of opposing personalities within past and current scientific discovery would prepare students for the group oriented project based curriculum at WPI.

Distribution of Work

Laura Clark – Literature Review, MBTI information, Biology/Chemistry course involvement

Girija Ramapriya – Course Observation/Feedback, Freshmen Seminar, Literature Review

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Introduction

Freshmen arrive at college anticipating a whole new style of academic enrichment. They expect to leave behind the predictable routine of high school classes and its set curriculum, to begin to develop a style of learning suitable to their independent personalities. Freshmen entering WPI however, describe their freshmen year as similar to their years in high school. It does not encourage them to independently raise questions regarding what they learn. We hope that the final outcome of our project is a course designed to bring WPI freshmen from a high school mindset to more of the college level experience they implicitly asked for; based on debate, questioning and probing, independent inquiry and hence leading to deeper comprehension.

The new freshmen seminars of WPI designed to address this issue are usually new courses co-taught by the science and humanities faculty. This raises doubts about what department will give them credit. Unless the courses are twice as long as a normal seven week course, and could then receive one credit from each department, the possibility of having a term-long course incorporating both technical studies and humanities work worth a full credit for either is questionable.

In our approach the new 'Freshmen Seminar' would be a one term Social Science course, and hence the students will get social science credit; but it is designed to compliment a science course already part of the typical freshman curriculum. It would be an ideal compliment to a B term Biology course, and be an acceptable co-course for someone taking Introductory Chemistry courses. It will pick up on the few Physics themes as well. Thus, it can go along with nearly any freshman science course offered, however, students enrolled in BB 1035 in B term are an ideal audience.

The reason for targeting this group is that the revised STS 1207 Psycho-Sociology of Science course, now called 'A-Bombs, Moon Rocks and the Discovery of DNA: The Influence of

Gender, Personality and Politics on Science,' will focus on the key biological discovery of the 20th century. The discovery of DNA raised questions on topics ranging from gender discrimination and scientific ethics to the nature of scientific discovery. On the other hand, it also touches upon the interdisciplinary nature of science, as chemists and physicists play a large role in the discovery of DNA, and are involved in the debate about the origin of the Moon as well. Included in this major discovery is an insurgency from the physics field, in the form of the Phage Group, that brings X-Ray Crystallography into biology and establishes microbiology; a field of study very different from the old style genetics. Cultural and organizational influences on the DNA discovery are notable, but the influence of external politics is better illustrated by the Apollo program and the reaction of the scientific community to its growing social significance in the post war era of the 20th century. Resistance to government direction of science is best illustrated by the emergence of the Pugwash Movement in the aftermath of the Manhattan Project and the Cold War.

Our proposed structure of the Freshmen Seminar would first require the students to read, write a personal book review and then discuss the book, The Double Helix by James Watson. The first week will be an introductory section on two contrasting views of science. The theories of normative science, how it is subject to external influences as presented by Robert Merton will be compared to Thomas Kuhn's Paradigm theory about the phases of science. Kuhn presents science as if it were isolated from external influences to make it clear what its internal dynamics are. The Myers-Briggs Type Indicator (MBTI) test will be administered within the first week of the course. The results will be returned and verified and used to create in-class themes. A discussion of how personality and cognitive styles affect group dynamics will be held in class the following week. An issue of class turnover was brought up this year. However when the course is limited to freshmen, students will rarely change or transfer in or out of a course once it has begun.

The personalities of the scientists as described in Watson's book will be discussed in MBTI terms, and this information will be the basis of an experiment to be conducted by each team. The

groups will have to complete team book reviews, a group mid term exam, lead in-class discussions regarding different psycho-sociology articles, and complete an assignment encouraging students to consider following in the controversial footsteps of Watson and Crick. After the mid-term exam, the course will discuss the origins of the Moon, the controversy, and how scientists' personalities affect their acceptance of evidence bearing on the validity of their theories. The course will end with discussions of the Pugwash movement, the politics involved, and the authority of the expert community. It will wrap up with explanations of how personalities and cognitive styles can affect how scientists regard their social responsibility. Professors teaching BB1035, BB 2920, or CH 1020 could take advantage of this opportunity and intertwine their lectures with this freshmen seminar, reinforcing the students' grasp of the subject. However, the course can stand alone as well, as it draws upon on materials the students have recently or will soon be exposed to in science classes.

In summation, this project is a proposal for a study to evaluate a new course. The new course will meet the objectives of a freshmen seminar in fostering critical thinking, group work, written and oral presentation, and debate/discussion. In addition the course will nurture a reflection of science, technology and the social context in which they operate. It would also teach introductory Psycho-Sociology with enough content on cognitive styles, personality and the sociology of science to deserve for a social science course credit. The course will be influential in preparing students for Qualifying Projects due to the focus on group dynamics. This course is designed to make science more engaging and important for prospective science students, targeting the Biology, Chemistry or Physics majors.

Overview

The topic of DNA is intriguing to a potential science major at WPI. There are underlying controversies surrounding the discovery of its double helix structure[1]. The most controversial act of Watson and Crick was that they used X-ray crystallographic pictures of DNA, taken by Rosalind Franklin, a scientist at another laboratory, without her consent or knowledge. Being a British female crystallographer trained in Paris, her relations with the male dominated science world in her lab in London at Kings College were less than ideal. Her isolation may have been due to differences in culture, personality or even gender. However Watson's account, which is an effort to relate his take on the events leading up to the discovery, justifies this act by presenting her as not being able to properly interpret her own findings. Luckily, there are several other accounts of the same events that allow a clearer picture of their scientific differences and how these developed into a conflict.

[1] Watson, James. The Double Helix: A Personal Account of The Discovery of the Structure of DNA (Harvard Press, Massachusetts, 1968)

Literature Review

The Double Helix written by James D. Watson is his account on the events leading up to the discovery of structure of DNA. The book is written through his point of view and touches on the interactions between him and the others involved. Although Watson includes sufficient analysis of scientific data to follow the events, much of the book is spent on his perception of the social scene around him.

Watson mentions in the preface that he "attempted to re-create [his] first impressions of the relevant events and personalities, rather than present an assessment of what occurred, taking into account the many facts [he has] learned since the structure was found."[2] Given this statement, before even reading the book, the reader is made aware that the account is biased. Many of the comments regarding fellow scientists' personalities and behaviors are simply his take on them. The best example of a controversial portrayal could be his treatment of Rosalind Franklin, whom he refers to as "Rosy". Other accounts never mention Rosalind being called that name by her colleagues, and her friends disputed Watson's description of her.

Being a woman scientist was even more difficult than it is today, especially with men like James Watson around. He does admit that at the time they were in "a scientific world which often regards women as mere diversions from serious thinking."[3] During the course of the book it never really occurs to him to listen to her opinion until he finds out later that she had been right all along, and that she did excellent science and was not just a "mis-guided feminist". Watson often talks about Rosalind's outbursts and personality flaws, which put Maurice Wilkins through "emotional hell". He also degrades her by daydreaming about what she would look like if she were more fashionable in her dress, instead of listening to her lecture. It is also interesting that he often says she was "anti-helical" when in fact she was just against the idea that the phosphate backbone was in

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[2] Ibid.

the center of the structure, and stated that it should instead be on the outside.[4] This of course is the basis for the structure that Watson and Crick will create, which further proves that Rosalind was a good scientist, and quite able to interpret the evidence she was collecting. For instance, she humiliated Watson and Crick by rapidly destroying their first effort to develop a model as clearly untenable within minutes of viewing it. The right structure might have been found earlier if they had listened to her.

The disrespect towards women was not solely focused on Rosalind. Watson also portrays Crick's wife as rather ignorant to science; talking about how she is forever decorating the home and going to parties. Watson also does not hold his intelligent sister in high regard, and contemplates about how he might get into Wilkins Lab if she got involved with the older but well-known scientist. It is interesting that Watson does not mention interest in anyone particular for himself. He appears to be trying to get the attention of women, but seems awkward and shy when not doing "science". So, although he does keep an eye out for a suitable spouse, his social life is not full of dating relationships.

Watson does a lot of thinking on the subject of the structure of DNA, yet he does not talk about doing a lot more other than model-building and listening to other scientists' theories. He does do some work in the lab, but it is mostly just a cover for his contemplation about DNA models. Watson does not portray himself as the most honest scientist, and even states that it is alright to steal another's work if they do not see the significance of it.[5] As an American, he also does not agree with the rule of thumb for science in England; that multiple scientists from different laboratories should not work on the same subject. The idea being that one can lay claim to a scientific question and have others respect that as your territory. Technically by this local custom he and Crick did not have any right to even think about the structure of DNA as Maurice Wilkins

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[3] Watson, James. DISCOVERY: The Double Helix (Harvard Press, Massachusetts. 1968), p. 226
[4] Watson, James. DISCOVERY: The Double Helix (Harvard Press, Massachusetts. 1968)

and his team, including associate Rosalind Franklin, owned the problem in England and should have been the ones to carry out the work on the subject. It is also peculiar that Watson often refers to the "race" between the two them and Linus Pauling of Cal Tech for the structure of DNA, though Pauling gave no impression that he knew of such a race, which he stated in a later interview. Even though Watson and Crick are credited with the discovery, Crick's role is downplayed in the book and the reader gets the sense that Watson was simply able to put together everyone else's theories and evidence. After several missteps his model building methods did work and the idea "just came to him". This portrays a cultural difference, in this case between the Americans and the rest of the world.

Even though Watson's methods seemed almost nonchalant towards science, he did see the potential importance of the discovery early on. Solving the structure of DNA led to solving the ancient paradigm of how life replicates. It was the basis of how genes and traits were passed from parent to daughter cells; and understanding how this all took place would lead to huge advances in science and give a further understanding of the world around us.

This book may not be the most accurate account of the discovery of the structure of DNA, but it presents an interesting point of view. It definitely captures the male British scientist temperament of the time in regards to women and science. Additionally, it brings light to cultural differences between the French, the English and the Americans. The book also lets you get a sense of the social scene behind science, and that the great scientists can be rather "regular" people. Watson reviews some of the science, which is fairly understandable for someone who has a basic knowledge of biology, although some information maybe too much for a non-biologist. This would be a good book to understand Watson's view, but to get a better picture of the social, cultural, and political scene surrounding the DNA discovery; it is recommended to read other accounts.

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[5] Watson, James. DISCOVERY: The Double Helix (Harvard Press, Massachusetts. 1968)

The course STS-1207 initially suggested reading the Anne Sayre book Rosalind Franklin and DNA to develop a better understanding of Rosalind Franklin, her social interactions and overall personality. Anne Sayre had access to Rosalind's scientific notes and was her personal friend, and also happened to be married to a biologist. However, the book didn't portray Rosalind well in terms of a psycho-sociology analysis. Being introduced for the new course is a new biography of Franklin written by a professional, Brenda Maddox. This biography is a good counter to Watson's account, and gives a more in depth view of Rosalind's personality and work habits. This book has been approved by her family and is based on her letters to her mother and father over the years, as well as interviews with family members and colleagues.

Maddox covers the lineage of Rosalind's family from the Middle Ages up until Rosalind's birth in London on July 25, 1920. Her family was upper middle class and rather influential. Her family also had a history of including some very intellectual people, which appears to have been passed on to Rosalind. Her father, Ellis Franklin, was a captain in the King's Own Yorkshire Light Infantry Regiment in the First World War and was released from service in 1918. He had married in 1917 to a woman named Muriel and decided to benefit the family by working at Keyser's Bank instead of studying science at Oxford. However, Ellis did end up teaching at the Working Men's College and later became Vice Principal. Muriel was very intelligent as well and had completed a high school education. She was denied a college education because her mother disapproved, and became a typical subservient wife as defined by Jewish tradition.

Muriel insisted on good manners and family loyalty, which instilled the practice of writing letters to family members on how you were and what you were doing. However, Muriel was also busy helping her husband with several charities and hired Ada Griffiths to be a Nanny to her five children. Ada saw that Rosalind was a bright child and helped her develop her skills, but sometimes even she tended to favor her brothers over Rosalind.

Rosalind was sent off to boarding school at Bexhill, where she attended Lindores School for Young Ladies. When she was eleven, she moved on to St. Paul's Girls' School to begin her middle-fourth form. Here she excelled in her studies, even though sometimes she thought she was being graded unfairly. Rosalind also participated in a number of sports and gained a close-knit group of friends. However, she never really learned the basics of life as most teenagers do around this age, and never really showed an interest in the opposite sex. Instead she enjoyed taking walks, going on strenuous hikes or bike rides by herself or with a friend or two. Rosalind also had a sense for fashion and developed her own sense of style, which was rather sophisticated.

After receiving high marks in science, Rosalind was off to Cambridge to attend Newnham College where she had won a scholarship. Here she threw herself into her studies and came across crystallography which was developed by Bragg and Bernal at Cambridge. Rosalind would later master x-ray diffraction as well and began to fine tune her picture taking ability. During this time the Second World War took place and Rosalind took a leadership position during drills on campus and helped with Jewish refugees from Europe. Her parents also helped with the refugees, finding them places to work and live in England. However, Rosalind and her father disagree on a few points regarding the war and would engage in heated discussions, which may have been a starting point for her harsh debating style.

After college Rosalind decided to find work as a chemist, preferably something that would support the war effort. She found work with R.G.W. Norrish researching the polymerization of formic acid and acetaldehyde. Rosalind found this work rather tedious and ultimately found an error in Norrish's' theoretical expectations and proved how it was impossible to figure out. This upset Norrish and they parted ways. Rosalind then found work with the British Coal Utilization Research Association. Here she had the title of Assistant Research Officer and could support the war effort. However, once the war was over Rosalind found new work in Paris with the help of Adrienne Weill, her friend who was a French scientist.

In Paris Rosalind worked with a scientist named Meering where she again could work on x-ray diffraction and crystallography and saw how they could advance her work on coal. She worked for a government research establishment and was allowed to conduct "pure research", or as close as you can get to this. Rosalind had also learned the French language, and was told that she spoke better French than some of the natives. She and the other scientists would often meet for lunch and discuss their work, which translates to scientists tearing apart each others work until a person's thesis was strong enough to withstand logical assault and was forcefully presented. Rosalind was unusually gifted at this tactic of destroying and undercutting the claims of other scientists.

Even though Rosalind worked hard in the lab, she also had a social life and was said to have had a crush on Meering, which may have turned into love. Meering was married but was a seducer who had supposedly slept with almost every woman he met on the job. He and Rosalind never had a sexual relationship, and Rosalind was jealous of mistresses he later took on, although ultimately accepted the role of "third" wheel which became a continuing trend.

Although Rosalind loved her life in Paris, her parents wanted her to return to England. The reason Rosalind originally went to Paris was because she could not find work in England, and soon an opportunity arose in J.T. Randall's lab working with the structure of biological fibers. Rosalind did not know biology, but she was willing to apply her expert x-ray diffraction skills to help research this subject. With the acceptance into Randall's lab she was back in England to begin her life changing work on the structure of DNA.

A controversial issue regarding the discovery of structure DNA involves an American scientist, Linus Pauling. By this time, Pauling had just discovered the structure of helical proteins, had the Nobel Prize, and was an active member of the Pugwash Movement starting in 1957. He had been an avid critic of American foreign policy much before that. The Pugwash Movement was

a realization of the need that scientists "can and should concern themselves with the fate of mankind[6]". As a result of the arms race, scientists decided that the public should be more involved regarding the implications of new technology, especially nuclear technology and weapons of mass destruction. The person credited with founding this movement was Lord Bertrand Russell, a British philosopher. As a plea on behalf of the human race, Russell's Manifesto describes the urgent need for an evaluation of the scientist's social role in relation to the development and use of weapons of mass destruction. One of the first scientists to sign the Manifesto was Albert Einstein; hence it was commonly referred to as the Russell-Einstein Manifesto. Following Einstein, another nine scientists signed the manifesto, including Linus Pauling. Several conferences were held worldwide, the first in Pugwash, Nova Scotia. In attempt to prevent Pauling from expressing his views on nuclear, chemical and especially biological warfare publicly, Pauling was denied the right to travel internationally by the U.S. State department which denied him a visa.

This restriction might have been a factor that hindered the advancement of his research on DNA structure as he was scheduled to visit London to visit his son, who was at the Cavendish with Watson and Crick. He also had asked Wilkins for data which Franklin had gathered and Wilkins put him off with an excuse. Had he arrived at King's College, Rosalind certainly would have met with him. Other accounts in addition to Watson's account of the DNA discovery have been developed during this time, and the controversies between labs, scientists, and people can be a very interesting study of how social factors affect science. Some are based on interviews, others are more traditional histories and some are by colleagues in the field. The idea that scientists interact as everyday people puts a different perspective on science than the accounts stressing scientific method rather than the intellectual quest or being in the right place at the right time, or even the Phage Group information and resource network.

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[6] Rotblat. 1972

A revolutionary shift in the concepts widely accepted in science is obvious with the discovery of DNA, and how it happened can be an eye opener for incoming freshman due to the role of personality and culture in a paradigm shift. It will encourage the understanding that what we believe to be the truth today could be overturned tomorrow. Further, that what we call a 'discovery' after the fact is actually a process involving anomalies, intellectual crisis in a scientific community and finally a semi-political process resulting in a new consensus. Then the text books report it as if it were a linear accumulation of factual discoveries so that the current framework seems to be self-evidently true. The book Discovery by Mahlon Hoagland does this to the DNA discovery itself. His account makes the process look Mertonian and Watson and Crick are considered minor players in the process. By contrast, most readers of Watson's book come away with new found respect for Thomas Kuhn. Kuhn, a promoter of the paradigm theory, states that "awareness is a prerequisite to all acceptable changes of theory", instigating personal inquiry.

In Thomas Kuhn's essay The Structure of Scientific Revolution, he stresses the major discoveries that occurred did so because it transformed scientific research to follow its path. Up until the 17th century, there were competing schools of thought regarding the same overall question of the nature of light. When Newton developed his theory, essentially encompassing all other theories under a main concept, Kuhn explains that it was the moment of emergence of one of the first paradigms. Future research from then on was based upon Newton's concept of Mechanics until Einstein's work on Quantum Mechanics and relativity. Franklin's work on electricity and Lavoissier's on combustion and oxygen are other examples of a paradigm revolution, but the Copernican revolution in astronomy overthrowing Ptolemaic theory was the classic example. For a theory to become accepted as a paradigm it must out perform its competitors, however it may still not be able to explain all the facts. Anomalies are the seeds of change.

A paradigm receives the confidence and aberrances of scientists if it takes into account that all facts that are relevant. Paradigms are frameworks of background assumptions, used when

theorizing to make science akin to puzzle solving. In order for a problem to be classified as a paradigm case, there needs to be a reason for using it to frame research. If what is being researched does not require re-conceptualization, nor will it affect global understanding in some way, it has no basis for becoming a paradigmatic example.[7] A functioning paradigm tends to focus and narrow a field of work, and make it a cumulative tradition in which there are guidelines and standards for evaluating research outcomes and claims. Many journals, institutions etc., are based on developed paradigms that support a research community. Interestingly, Kuhn points out that historically, the scientific research papers tend to omit important facts and details, and focuses instead upon inconsequential details, as the rest is taken for granted as common lore.

Normal science deals with what is expected as an outcome; hence it is never an object of replication. The normal foci for scientists, as Kuhn states, are to find facts, and demonstrate agreement with the prevailing paradigm – not challenge it. They develop inventions, vaccinations, and useful technology from institutionalized paradigms. Normal science, according to Kuhn, is a matter of complex puzzle solving, and creating a set of rules for that specific field of science. When unexpected findings emerge it is not a welcome 'discovery,' he describes the emergence of anomalies as provoking a community wide crisis of confidence.

In comparison to Mertonion theory, Kuhn's theory demeans the scientist, making him less than the objective seeker of truth. Priorities in Scientific Discovery: A Chapter in the Sociology of Science, Merton discloses his belief that the disputes in science are over priority, not "their cause or grounds". Scientists may reach the same solution independently, and the question is then who has priority for the discovery. Merton considers the possibility that the reason for the disputes occur is simply due to human nature, or perhaps the fact that science tends to draw in "ego-centered people,"[8] however; he then rejects that kind of psychological explanation. A significant number of

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[7] Kuhn, Thomas. The Structure of Scientific Revolution.
[8] Robert K. Merton. Priorities in Scientific Discovery: A Chapter in the Sociology of Science.

conflicts in science have occurred between men who are described as modest and are only looking to find answers, not fame, thus he points to the institutional norms and reward structure of science to explain its competitive nature, and the emergence of priority disputes surrounding multiple claims of discovery.

Merton states that the explanation lies in the institution of science, as its norms call for scientists to claim and publish their findings. The scientists themselves may not be looking to publish, but their colleagues often push them to quit polishing and refining their work and stake a claim to get credit for being original. Getting recognition for their work is the reward in science, so even the most introverted scientists are pressured to seek out fame. According to Merton, the highest honor is "eponymy" - to be named a father or mother of a scientific field. The next level of honor would go to the one who had created a law, theory, constant, etc to be named after them. When receiving such recognition, the scientist is also expected to express some humility. This pulls scientists in two different directions, for they are taught to insist on deserved recognition, yet be humble, and acknowledge the work of those who came before, minimizing their own contributions.

The two different principles may be blamed for some of the problems in science, one of which is fraud or plagiarism, claiming the work of another as your own. The "pressure to demonstrate the truth of a theory or to produce a sensational discovery has occasionally led to the faking of scientific evidence"[9], and many literary documents and data sets have been altered. Fame and money are also driving scientists to falsify data, some simply by "trimming" out data that does not fall within the desired range. Forgery is also a problem in science, driven by the need to do something truly original to get recognition. Replication studies get little respect unless they overthrow a long standing claim taken to be true.

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[9] Ibid.

Merton's science has a certain set of values, norms, and organizations. The reward system for this institution drives scientists to opposite ends of the spectrum, humility and priority. This creates certain attitudes and can lead to fraud and forgery. Merton says that even though the norms of science are based on good values, the structure today causes a lot of stress and pressure and reminds that "unrestricted belief in absolutes has its dangers too. It can produce the kind of fanatic zeal in which anything goes."[10]

In the case of DNA, it is not that the substance or even the structure of the substance was factually 'discovered.' The implied process of replication, determined from the structure, was what mattered. In prior episodes, such as Lavoisier's 'discovery' of Oxygen, the important point was not oxygen as an element, but the theory of combustion, which gave oxygen a prominent role; and was able to be generalized to phenomena as diverse as fire, rust and breathing. A new paradigm is created as much as discovered and the image of the scientist is dramatically affected by Kuhn's revision of the process whereby science 'advances.'

However, one account of the DNA case does present the discovery as a set of incremental factual discoveries, and gives a Mertonion view of the same situation which Watson so dramatically describes as a breakthrough. Mahlon Hoagland develops an interesting perspective of the evolution of genetics, from the early beginning to the progressive, elegant molecular genetics of today, in his book DISCOVERY: The Search for DNA's secrets. His portrayal of science as it should be contradicts Kuhn's paradigm change image of scientific advancement as a revolutionary episode. Each major advance in the world of genetics is laid out linearly, as a time line of extensions from other research, much like textbooks portray the work as one thing built on the last in logical progression.[11]

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[10] Robert K. Merton. Priorities in Scientific Discovery: A Chapter in the Sociology of Science.
[11] Hoagland, Mahlon.

The scientists, unexpectedly, are not described as great intellectual beings that have shaped the world's view on how life is replicated, but rather as dramatic characters with emotions real as life itself. Within one hundred years of investigations, Hoagland points out that humans had deciphered and understood the rules of genetic inheritance.[12] His view regarding scientists somewhat contradicts his portrayal of science; their results become prophecies and predictions of the uncertainty concerning evolution's future. They are the explorers of the new century, yet have been able to collaborate with the nonscientific culture, to enlighten the newfound knowledge for all. Hoagland's portrayal of exceptional acts of science in such a matter of fact, almost casual manner, provides the technical background to bring awareness to the intellectual steps involved with scientific discovery, making them small enough so that great work is done by the community, but no one needs to be a genius.

The chapters are laid out in a chronological order, as he describes that "Each idea and great venture has its time and place"[13]. He discusses it as if each discovery were an obvious step from the last; however, the reality of the experiments was of hundreds and trials and errors by many scientists. The ideas are "born and raised with the tenderest of care" Hoagland describes, they are created from previous knowledge and paradigm shifting view points[14]. As a new paradigm on genetics was established, the research shifted onto the newest discovery. Hoagland points out very well that the acceptance and knowledge of such experiments/results took time. Gregor Mendel, the Father of Genetics, was the first to officially observe and understand inheritance. His work however, was forgotten for over 100 years, until Thomas Morgan and Hermann Miller discover chromosomes and mutations.

As more information was discovered, more concrete knowledge on genes and DNA developed. Thus, scientists such as Oswald Avery, George Beadle, Ed Tatum, Salvadore Luria and

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[12] Ibid.
[13] Ibid, 13.

Max Delbruck were able to advance much further, in only 100 years. Not only was the necessary technology available, but the answer to how life is stored and replicated was so close. Although the linear progression is emphasized in Hoagland's book, he discusses the skeptical nature of other scientists when a new discovery is made[15]. When Avery heard Griffith's experiment, he was cautious due to the fact that Griffith's results did not match the consensus and current knowledge. Interestingly, this skepticism is not as prominent during the acceptance of DNA's discovery.

The result of DNA's double helical structure had confirmed previous knowledge, and was in fact, just a compilation of all scientists' work and put together. The presentation of Francis Crick and James Watson's work is quite simply laid out, almost implying that their monumental discovery for the structure of DNA was only a small piece of the larger picture.

Hoagland, by bringing vigor and emotion to the scientists, allows the sometime opaque language of science to enter the vernacular. The reader connects with the scientists, and hence the work is regarded as regular evolution of thought. Griffiths is described as "a sad and lonely figure," however the research and the great interest he had in it came across as almost obvious[16]. Hoagland brings sympathy for the scientists; by doing this, the personality of the scientists seem to stand out more than their experiments. Other scientists, such as Avery and Oswald were the more typical scientific stereotype of analytical, skeptical researchers requiring proof for any claim.

The scientists seemed to fine tune the previous work; and interestingly, Hoagland considers the previous work substantially more important than Kuhn's model would have it. Without the first work, nothing could have developed, however the speed of which everything occurred, a burst of scientific discovery was incredible. One of the more obvious dramatizations of how scientists act occurs later in the book. Brenner and another American scientist were

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[14] Ibid. 57

competing on the topic of co linearity, where DNA and protein are linked. However, when the American scientist was coming to Cavendish to discuss their findings, Brenner decided to put together a presentation on his newest findings, inviting not only his 'rival', but other prominent scientists, including Francis Crick, John Kendrew, Seymour Brenzer, etc.

The presentation was perfect, impressing all, and depressing his rival terribly. Suddenly, Crick left the presentation before its grand finale; soon others too caught on and all finally realized that the whole presentation was a hoax! A practical joke never seemed so appropriate, and yet these were men of stature and importance[17]. This kind of portrayal of scientists allows the reader to not only relate to the researchers and the experiments, but understand the interpersonal byplay and politics of science. Relating to Watson's book, The Double Helix, one learns about how the different personalities within the scientific world really do matter, and how interaction patterns have career implications. Interestingly, the nature of Rosalind Franklin, nor Watson or Crick, is not mentioned in this book by Hoagland. He is too busy making sure that all those he considers to have been more important contributors, who laid the foundation for their moment in the sun, get their due and come out of the shadows to take a bow.

This account, although very important to portray the discovery of DNA's structure as evolutionary rather than revolutionary, would not be worth reading in its entirety for the class. The amount of detail presented, and the drawn out descriptions of science can be numbing and overwhelming, to the point that why the book was assigned, gets lost. Thus, a chapter focus for students on the teams assigned to cover this account and descriptions of the chapters which are not as important is offered below. The chapters which students should focus on include: 4, 8,9,10,11,12,13. The rest we have summarized for them so that they get the evolutionary

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[15] Ibid 19
[16] Ibid. 16
[17] Ibid. 141-142

message but can focus on the part in which Hoagland's account of the actual discovery differs from Watson's, or Maddox's account.

Chapter One:

Chapter one begins "the tale of discovery" from the very beginning. Describing the works of the monk Gregor Mendel, the idea of genes is introduced. The reason for Mendel's work was because the monastery which he resided in was interested in the breeding of plants and animals (2). Working with pea plants due to the ease of noticing change, i.e. color, shape, height etc. He "mated" one plant with specific traits with a plant with opposite characteristics. Studying the next generation, he concluded that traits were passed down, and identified the four possible outcomes for crossing two genes, dominant and recessive. Thomas Morgan worked with another small scale model, fruit flies. Through his work chromosomes were identified as the carriers of genes. Still unknown was that chromosomes contained DNA (5-10). Hoagland also discusses the four bases in DNA, adenosine, thymine, cytosine and guanine, along with their sugar-phosphate backbone. He introduces the full topic in detail, while still discussing the beginnings of modern day genetics. Muller's work, Hoagland discusses, gives light on mutations and the nature of its occurrence. He also starts using bacteriophages as models for scientific work.

Chapter Two:

Genes are finally "discovered" by Oswald Avery in chapter two. Avery worked with the pneumonia virus and rats, and by discovering that even though the virus was heat killed, it still killed the rat. He discovered genes, and proved Griffith's experiment on gene transformation - or gene transfer. Avery is the only scientist mentioned who did not receive a Nobel Prize for his work, yet was as successful as any other scientist discussed. The long strand found in Avery's experiment led to an elegant discovery that DNA was the actual piece of the gene that held the genetic information. The Al Hershey-Marth Chase experiment proved that hereditary information was

carried by DNA and not protein, via their separation of bacterial DNA and phage infections. This chapter also describes the start of the famous Phage Group. Next, Hoagland discusses the work of Henry Beadle and Edward Tatum's experiment on common bread mold. They discovered a relationship between mutations and abilities to survive and adapt.

Chapter Three:

This chapter describes the Phage Group led by Max Delbruck in more detail. First, Hoagland emphasizes the use of bacteria as models for evolutionary and genetic work because the generation time of bacteria is very short. Within twenty minutes, the daughter cells of the original bacteria can be mature and ready to work with. Also, the affects of mutations etc. are more easily noticed with bacteria when the experiment is spread on a plate containing different media which the bacteria grows on normally. With work and support from Delbruck, and Hershey, and the rest of the Phage Group, Luria helped show the nature of spontaneous versus induced mutations. The Luria-Delbruck experiment is a classic example of mutations developing spontaneously for survival, illustrating Charles Darwin's theory of evolution.

Chapter Five:

Chapter five is a review of what was known about genes thus far. Genes, up until this point, were known to be "discrete physical entities" that could replicate exactly, meaning it could clone itself. Genes could also become mutated, and are responsible for cell function. Chromosomes contain DNA, and since DNA can be inserted into other cells, it is responsible for inheritance, hence genes are DNA. Further, the number of genes must be at least the same number as that of proteins found in the organism. Mutations and its importance to "elucidate living function" (60-63) are mentioned. This chapter also illustrates the "sequence hypothesis." Francis Crick, in 1957 formalized the question, how the sequence of amino acids in proteins was determined by the sequence of nucleotides of DNA. Going into much detail, Hoagland discusses methods for

mutation analysis to determine function of DNA. Relating back to work with bacteria, the function/sequence relationship was easily noticed, because when bacteria are plated, but they are mutants with one necessary gene missing, you will notice it when they are not growing on specific media. This method of screening is used widely to this day.

Chapter Six:

Joshua Lederberg's discovery of sexual gene transfer in bacteria is mentioned in chapter 6. He worked under Tatum, and his work was inspired by Avery. With the use of bacteria with different genes, he analyzed the progeny, and deduced that the progeny would only have certain genes if and only if the bacteria exchanged genes. He found out that the genes are transferred via conjugation. William Hayes took Lederberg's work further, by discovering that bacteria could be classified as F+ or F-, essentially the same as male and female. This established the theory of genetic recombination, and thus, the work of scientists shifted further into gene function.

Chapter Seven:

Francois Jacob and Elie Wollman, with their work on bacteria, mapped out the sequential gene transfer that occurs when bacteria mate. By using antibiotic sensitive females, and resistant males, they combined them in a tube, and quickly removed them once the start of gene transfer occurred. This showed that a different amount of genes were transferred to the females, and only the ones that received the gene for resistance against the antibiotic could actually grow on the plate. They knew where the gene for resistance was, from gene mapping, so they understood that when they stopped the gene transfer early, the gene for resistance wouldn't insert into the female. This long strand of genes, and sequential insertion helped understand DNA better, by showing that genes are long strands of information. This paved the way for the rest of the Phage Group and researchers to discover the structure and function of DNA.

This is the point where the presentation team should take over and read chapters 8-13. These chapters tell the story of the DNA discovery and its aftermath. Watson and Crick's work is covered in part of one of these chapters; Franklin is barely mentioned in only one line of that chapter. The colleagues award scientific credit rather differently than the Nobel Prize committee or the public.

The in-class discussions regarding scientific discovery and the effect of personality and cognitive styles will then lead the class into the topic of Apollo Scientists and their controversy about the three competing theories of the origins of the Moon. The psychology of the three speculative theorists most closely associated with the three theories and the other 42 most involved scientists was studied. The pool of 42 was later categorized as "types" of scientists using the scientists own words in describing each other, and the MBTI which was administered to them. They were given the MBTI both to see how they differed from the general population, and to see if their stereotypical classifications of each other were grounded in these variables[18]. The scientists did feel that personality differences had affected their ability to come to a consensus on the origins of the Moon. But in the end, one scientist, Harold Urey[19], yielded to his colleagues and decided the evidence was against him. The field moved toward consensus, and away from Mitroff's theory that no one would yield, or change their minds, based on the evidence; however that process took ten years.

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[18] Mitroff, Ian. Subjective Side of Science.
[19] Brush, Stephen. "Urey and the Origin of the Moon," Science 217. 891-898

Overview of Added Material

This is the kind of course that will encourage students to do some critical thinking and be aware that what they are taught in the classroom is as much a matter of group interpretation as fact. The ability to identify and examine discrepancies between different schools of thought to achieve a reasonable synthesized argument is prized in science and key to resolving crises. This class will allow the student to ponder great science in the past and then participate in independent research, develop much needed skills for discussion and presentation, and require personal investigations deep into the subject that they are learning.

The group work and independent research will enhance the subject matter and prepare the students for the upcoming project based education (or WPI Plan) which WPI specifically designed to prepare students for future careers as technological-humanists. The material, as described below, which would be presented in the course, balances teaching about the MBTI classifications of personality and the GCSI methods for determining cognitive styles will engage the students in their group work. Since they will know their own differences on the same measures and be analyzing how such differences have affected past scientific discovery, they can reflect on their own experience in their teams. There will be presentations about how past WPI students (of their types) fared at WPI in both teamwork and classes, so the freshman will be encouraged to think about their time at WPI as well as their future careers and technical contribution. This introduction to the psycho-sociology of science will show how cognitive differences can affect group dynamics, and while this class provides an experience working their cognitive opposites in terms of personality. This experience will help them understand and overcome certain issues regarding differences in communication pattern, social skills and work ethic among their group members, and develop the much needed ability to tolerate and draw strength from cognitive diversity. This will improve the chanced for successful group work later at WPI.

The MBTI system for measuring psychological type, developed by Katherine Cook Briggs and her daughter Isabel Briggs Myers, is an effort to operationalize Carl Jung's theories on the functions of the conscious personality; He stressed sensing versus intuition, introversion versus extraversion, and thinking versus feeling. Briggs and Myers developed the indicator during World War II as a way to estimate personality type. The outcome was a series of questions focused upon personal preference in a dichotomy. There are 4 dichotomies that can be used to define 16 psychological types, which separate into Extraversion / Introversion, Sensing / iNtuition, Thinking / Feeling and Judging / Perceiving. Individuals will rarely exhibit all of the associated tendencies, which refer to preference rather than cognitive abilities. The description of each type is as follows:

The E-I Dimension:

Extraverted Characteristics

* Act first, think/reflect later.

* Feel deprived when cutoff from interaction with the outside world.

* Usually open to and energized/stimulated by outside world of people and things.

* Enjoy wide variety and change in people and personal relationships.

Introverted Characteristics

* Think/reflect first, and then act.

* Regularly require an amount of "private time" to recharge batteries after social interactions.

* Energized or simulated internally, mind is sometimes so active it is "closed" to outside world.

* Prefer one-to-one communication and relationships.

The S-N Dimension:

Sensing Characteristics

* Mentally live in the Now, attending to present situational realities.

* Using common sense and creating practical solutions is automatic-instinctual.

* Memory recall is relatively accurate and rich in detail of facts and past events.

* Best at improvising from past experience.

* Like clear and concrete information and assignment instruction; dislike guessing when facts or expectations are "fuzzy".

Intuitive Characteristics

* Mentally live in the Future, see potential, and attend to future possibilities.

* Using imagination and creating/inventing new possibilities is automatic-instinctual.

* Memory recalls emphasizes patterns, contexts, and connections, but not specific factual details.

* Best at improvising from theoretical understanding.

* Comfortable with ambiguous, subjective data and reading between the lines to understand its meaning.

The T-F Dimension:

Thinking Characteristics

* Instinctively search for facts and logical frameworks to structure a decision situation.

* Naturally notices tasks and work to be accomplished.

* Easily able to provide an objective and critical analysis, dispassionate.

* Accept conflict as a natural, normal part of relationships with people, emphasizes justice in making decisions that affect others.

Feeling Characteristics

* Instinctively employ personal feelings and uses empathy to identify with the people who will be affected in decision situations.

* Naturally sensitive to people's needs and reactions; Does not avoid making subjective connections with those impacted by one's decisions while seeking the best outcome in the given situation. Not concerned with precedents and justifying a decision in terms of general principles.

* Naturally seek consensus and popular opinions.

* Unsettled by conflict; have almost a toxic reaction to disharmony.

The J-P Dimension:

Judging Characteristics

* Gather just enough information about a situation to make a grounded a decision.

* Developing a plan and sticking to it is preferred.

* Focus on task-related action; complete meaningful segments before moving on.

* Work best and avoid stress when keeping ahead of deadlines; Work first then play.

* Need structure, closure and routines to manage life.

Perceiving Characteristics

* Want as much information as possible before making a decision.

* Comfortable moving into action without a plan; plan on-the-go, flexible.

* Like to multitask, have variety, mix work and play.

* Naturally tolerant of time pressure; work best close to the deadlines.

* Decisions made are "tentative", still open to revision based on new information that may arise.

[20]

[20] http://www.personalitypathways.com/type_inventory.html

There are 16 possible combinations, or personalities, that are created by the interaction of these 4 dimensions. The numerical value associated with each dimension is a metric on the consistency of the responses and indicates the reliability of the classification on that preference variable. If, after a feedback and information session, the person taking the test does not agree with the outcome, they are allowed to overrule the indicator and designate which type they believe themselves to be for the purpose of group assignment. The MBTI is used in a variety of situations regarding group activity. Our project will focus on the application of the MBTI Personality Indicator to distinguish between learning styles and assess conflict potential in group dynamics.

Everyone does not learn in the same way. One may prefer to learn by seeing, another by doing. Some prefer group work, others to work alone. For some multiple choice tests are easy, others do well recalling information for essay questions. It is shown that personality type correlates to learning styles, and can help identify preferences, as well as possible weaknesses and strengths in students. For example, people who score in the I or J category are said to have a traditional ethic of hard work. J also is associated with good goal orientation, time management, and long-range planning. On the other hand, the S category, especially the combination SP, are said to be a learning risk. These types will ignore or postpone difficult conceptual tasks and will tend to get help from friends rather than master materials on their own. On the other hand these types have shown to be able to troubleshoot and improvise well and can create a workable solution if the group runs into difficulties. If these two different types of people were put into the same group, then the consistent hard workers could help keep the people at risk of procrastinating in line, helping them

learn to prepare in advance, and the troubleshooters can help the consistent hard workers think "outside of the box" to create new solutions.

Another aspect to take into consideration is how people learn in lecture. Studies have proven that I, F, and P types are easily distracted and have poor attention control.[21] Also, EP and TP combinations need spontaneous activities to keep themselves engaged. A solution to help these students learn would be to implement more group work and fewer lectures. This would go along with an ES learning environment, which is said to be the most productive regardless of which type a student is. The ideal learning environment for an E has active experimentation and collaborative learning because this type requires a lot of stimulation.

Science is increasingly becoming group oriented; an interdisciplinary, collaborative approach is being applied to many scientific questions requiring cooperation between physicists, biologists, chemists, engineers etc. Since the Project Plan at WPI prepares students for the 'real world,' knowing how to succeed in interdisciplinary group work is an essential skill. The results from the MBTI Personality Test results will benefit a student by giving an insight to their own learning style, as well as an experience with cognitively diverse group dynamics. The MBTI information incorporated within this course's curriculum will help students to recognize the implications of the fact that different personalities are associated with different work habits. The students can then learn to accept their peers' differences and try to work with them rather than against them to create an uncomfortable task environment.

The validity of the MBTI Personality indicator is under debate in psychology literature. The creators of the test had no scientific background and Jung's theories were based on clinical observations, not scientific studies. Also, since the types are set up in theoretical dichotomies, one would expect the distribution of data to congregate towards the ends of the

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[21] Myers MBTI Manual (Palo Alto, CA: Consulting Psychologists Press Inc., 1998 3rd ed.).

spectrum.[22] However, the data from the MBTI indicator creates peaks at the center of the spectrum, making the division of preferences by the mean value rather arbitrary. As a practical matter, this means that people could easily be misclassified and swing from one side of the mean to the other by small empirical differences. As a theoretical matter is raises the question whether the theory is wrong about the dimension being dichotomous or the measure is a poor operationalization of the truly dichotomous construct. As a pragmatic response to the potential for misclassification, there are feedback and verification procedures. When administered the test, people are allowed to challenge the results and chose which classification they feel is the best fit for them. People who retake the test sometimes score differently, again raising the question if the test actually measures stable underlying types. On the other hand, most people have found the results to be pretty accurate and 85% typically agree that they have been successfully typed on at least 3 of the 4 dimensions. Even though the validity of the test as a reliable measure of the Jungian theoretical construct, there is little doubt that MBTI differences in preference are generally stable, reliable and correlate with important individual and group performance measures, as well as educational testing outcomes. While the indicator has been questioned, it has proven to be helpful. It is especially useful in providing a language that is non-judgmental for talking about personal differences. It certainly helps one in understanding many potentially difficult situations, such as providing an insight to conflict and performance in group dynamics. WPI could use a common language of this type, systematically introduced throughout the Freshman Seminar Program, to raise consciousness about important personal differences.

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[22] Allen L. Hammer, editor MBTI Applications (Palo Alto, CA: Consulting Psychologists Press Inc., 1998 3rd ed.).

Methods / Content

The title of the proposed class, SS 120X is "A-Bombs, Moon Rocks and the Discovery of DNA: How Personality, Culture, Gender and Politics Affect Science." As stated previously, the course will delve into discussions based upon the different DNA accounts, one written by Watson himself, and three others written by colleagues, journalists and historians. These accounts do not agree on the importance of the Watson and Crick episode and contribution; however they do agree that there was something intriguing about their fruitful relationship and that the competing Wilkins-Franklin collaboration was dysfunctional and possibly pathological. The accounts do admit though, that the Wilkins-Franklin team had several advantages and probably would have won the race if not for their personal antipathy. One of the accounts, states that their "personality clash" was complicated by gender and the fact that Rosalind was just back from being "de-Englished" by several happy years in a French Lab, so it is not clear which factor; gender, culture or personality was the most important one. Cognitive Style and personality theory will be used to characterize these two critical relationships, and the possible factors limiting their success.

The course will also cover the community of 42 Apollo "Moon Scientists" whose theoretical debate on the origins of the Moon was transformed from a speculative debate involving three theories to an empirical study as actual samples from specific parts of the Moon were brought to Earth. This topic will tie in recent theories and research, and provide specific examples of how other scientific discoveries can become entangled by personalities and cognitive styles, and be even more affected by external political and economic factors than the DNA case.

Finally, a key member of the DNA race, Linus Pauling, was involved in a movement to create a new more socially concerned kind of science. The group's members named themselves after the location of their first meeting, "Pugwash" (Nova Scotia). Pugwashers were encouraged to take their political and social concerns about weapons research, the environment etc. to the

public. The Pugwash movement's growth from 20 odd American, Soviet, English and Chinese scientists meeting in Pugwash Nova Scotia during the height of the Cold War to a hundred or more eminent scientists meeting in Vienna, Moscow and London over the next ten years, and helping to keep the Cold War Cold during the Cuban Missile Crisis is an amazing story. These and the meetings from the US's "Star Wars" years under Ronald Reagan, when a new arms race was a threat, resulted in Pugwash getting the Nobel Peace Prize in 1995. Discussion of this movement by the scientific elite and an introduction to the leaders of the WPI Chapter of Student Pugwash will not only bring awareness of scientist's social responsibility but also the possibility of continuous involvement in the socially concerned science in movement in the present, while still a WPI student.

In this course future scientists and engineers will be called upon to carefully examine and thoughtfully consider potentially embarrassing (and normally taboo subjects) specifically the subjective factors that affect science. Science is not as rational and objective as its public image creates tensions between science and the public that supports it. Unreasonable public expectations are combined with unusual prestige, influence, and financial support. Understanding the psycho-socio aspects involved with a major scientific discovery will enable seminar students to be realistic in their expectations and future plans. They should not expect too much of themselves and other scientists in terms of living up to the norms of science but should still understand why the institution works well despite the ethical lapses of individual scientists. However they will also become aware of what political and economic trends are threats to science as an institution and why/how to mobilize the public to help scientist resist them when necessary.

Seminar Goals and Overview

This proposed freshmen course is designed to aid students in their academic evolution from passive to active learners, as they adjust to the WPI curriculum, specifically the Project Plan. The seminar objectives include:

1. Engage students in critical thinking about the social institution of science, and acknowledge the role of personality, culture, gender and politics in scientific success and team accomplishments

2. To enable students to deal with strikingly opposite personality types through an understanding of the MBTI personality typology and its implications

3. Prepare students for a team work centered and project-oriented curriculum by studying team dynamics within great scientific discovery

4. Shed light on how ethics and social responsibility issues come up in the course of doing science and how psycho-sociological factors influence the stands scientists take on their social responsibilities toward the general public, and the governmental organizations that support the institution of science

5. Develop skills regarding public speaking and professional writing experience by leading in-class discussions, writing literature reviews, and presenting their project results to the class

6. To provide a language for talking about the psychological differences at the cognitive styles and personality levels, and use it within the course, so it will be familiar later, when team dynamics and learning style issues become important to their success at WPI

There is also the possibility of synchronicity between this course and other courses offered to freshman by either the biology or chemistry departments. Courses in biology or chemistry would be proper forums to discuss the technical aspects of microbiology and DNA, as well as the ethical treatment of colleagues. By contrast, this course would be the place to delve into the larger sociological aspects and the psychology of team dynamics and conflict issues. The connection with the Biology and Biotechnology department is especially useful to the disproportionate number of female students enrolled in that major. This course discusses the gender issue directly, and although the stereotypes are not as strong as they were 50 years ago, discrimination can and does still become an issue. Two famous cases of female scientists with atypical careers, Rosalind Franklin and Barbara McClintock, both working on biological issues, are examined in this course. In both cases scientific style, personality, and gender become intertwined to marginalize the scientist for at least part of her career. The information covered in course will prepare students to recognize such issues, understand their potential consequences and deal with them should they come up. Running the classes as parallel freshmen experiences is not a necessity, but it would be beneficial. This freshmen seminar could give special priority to incoming students in the BBT major, who want to register for this seminar.

Assignments

Grouping Method:

This procedure describes how to create diverse groups based upon the preference dimensions from the MBTI Personality Indicator that deal with how one prefers to process information and how structured a task environment one prefers. Once the results from the indicator are received, first note the distribution of N/S and J/P types. According to the number of students in class, decide how many groups are needed; for example a 30 person class would have ten groups of three. Divide equally the students who are N and S, and J and P. The two most common types, NP and SJ, should be first priority when distributing students into groups, and the NJ and SP would be second priority. Next, take into account E/I and T/F, to make sure they are equally represented, making the groups as diverse as possible. Use the factor weights to note how reliable the results are when making assignments.

Discussion:

The majority of the discussions in this course would be facilitated by the student groups. For each discussion, a certain group will have the responsibility to read, summarize and put together questions to lead the in-class discussions. In some cases, the professor will coach the group on what to look for in reading an article, helping them identify the important points relevant to this course and distinguish them from other details. The professor will moderate the discussion and turn to other key points, finalizing which topics should be stressed in the notes for that specific discussion. However, the group would be responsible for the majority of the class. The professor will create a model for the discussions by facilitating the first discussion based on the assigned readings by Kuhn on "paradigms" and "normal science" and Merton's article on the "Puritan Spur to Science".

There are two reasons for putting in-class discussion responsibility on the groups; one is that it will spread the work load for reading over all students for the class as a whole, and give particular teams days off from reading for that class discussion to prepare for the ones in the future that they will lead. Each group will be assigned to one discussion topic or article. This way the articles will be spaced through out the term to ease the student work load, to be understanding of the fact that other freshmen courses at WPI require a lot of daily assignments; the math, physics, and chemistry courses shared by almost all incoming students have weekly homework problems which take up a lot of students' time. However, this does not imply that this seminar will not be less important or demanding than other freshman courses. The other students will have access to each of the articles to give them the option of reading it in the original anyway, if it is not their group's turn to lead the discussion.

The second reason why the groups would be in charge of discussion is to teach the students valuable skills in oral presentation, preparing hand outs and leading meetings. There are certain skills that the students will gain from each other, such as engaging the class, informing them about the subject, involving the others to participate in discussion. The team themselves get a role in the overall planning of the course presentation beforehand and have a deadline. These skills are necessary for all types of group orientation, including campus group leadership, project group development and success in internships, co-ops and junior professional experiences will serve them in their later careers[23].

[23] Ganz et al. Breaking the silicon ceiling: women in engineering. IEEE 2003.

Activities

The first group activity, "Observing a Leaf," will be performed during the end of the second week of the term and is designed to introduce the students to their particular group, and bring out each student's particular personality type. Each student in a team will get a card saying 1, 2, 3 or 4. The ones will go to NP students, the 2's to the SJ students, and the 3's to SPs and 4's to NJs. If the NJs are few in number, they will be added to the NP group (1) and if the SPs are few in number, they will be added to group 2, the SJs. The card assignment will be treated casually, as if random. The 2 to 4 teams will form and each member will write down what comes to mind as they observe a leaf using a flip chart to write down their answers. The two groups will work independently preferable in different rooms, for 10 minutes. They will then regroup and compare lists. The reason behind observing a leaf is to demonstrate the significance of the intuitive personality preference versus the sensing personality preference difference. This activity will show how each person, with regards to their own preference, takes in information and processes it to answer a specific question, and where their style of perception takes them. This project is suitable for the beginning of the course because it begins group interaction in an informal setting. This is to help break the ice, and recognize the nature of cognitive diversity used to form the groups, and how that might lead people to tackle given problems in certain ways.

The next group activity is an experiment on social networks, and group dynamics. The students, in three large groups, made up of 3-4 small teams, each of which is given a third of a final solution. Their task is to come up with the most promising solution to all three parts of the problem. Since they are lacking two of the three, and know that the other groups have the rest of the solution which they need, friendly competition is encouraged. The three team answers will be ranked 1, 2, or 3 and get an A, B, or C as a result. The possibility of collaboration is also raised, but that means a B for the entire class grade. Further, they must not get caught using unethical means

of data gathering; if caught the consequence is a low team grade of a D. This activity is analogous to the laboratories which Watson and Crick (Cavendish), Franklin and Wilkins (King's), and Pauling (Cal Tech) worked in, and were in 'competition' for deducing the structure of DNA. This activity is also mimics the focus of a WPI education, science and engineering.

The actual assignment crosses the biology, nuclear power and space themes of the course to pose that a contract competition from 'LUNA Corp' is being held. The objective is to establish an agricultural facility on the Moon, that is expandable to the point of being capable of supporting a Helium-3 mining community of 500 people. Soil, gas and energy supply for an underground facility due to the need for shielding from cosmic radiation are all needed and each team has a workable answer to one of these problems as a starting point. The experiment enhances the social aspect of scientific developments by requiring the students to invent and assess the feasibility of a plan yet to be implemented in real life. However, since the experiment has such a strict time limit, not only does the experiment require creativity, but their task could be simplified if they knew what the competition was doing. For example, if a lab can recruit one member of another lab group to share their third of the necessary information, that would change the odds of success. To do this one group would need to recruit a marginalized member of another team, as Watson did Maurice Wilkins, to be disloyal to their teammates for personal gain of some kind. Maurice's disloyalty to Rosalind and the rest of his lab gained him a share of the Watson and Crick Nobel Prize.

The third group activity is a series of comparisons of different accounts of the DNA case with that of Watson's book. These group reports and presentations give the students an alternate view of individuals involved with the case, and thus provides insight to the scientists' personalities and cognitive styles. The reports will be based around the DNA accounts by Mahlon Hoagland, Horace F. Judson, and Evelyn Fox Keller's book about Barbara McClintock (which is called "A Feeling For the Organism").

The final group activity is more of an analysis of their work so far, as reflected in the personal diaries on the team work, and how group dynamics were affected by personality and cognitive style differences. An in-class assignment will ask the students to reflect on their group work so far, in this class (and in other classes if applicable), and analyze how they overcame certain clashes of personality and group communication challenges. If a group division of labor emerged that would be examined in terms of both the GCSI and MBTI measures administered to the class and used to elucidate the complementary that emerged in the DNA case.

Evaluation / Observation

Book reviews from D term 2007 offering of the original course, STS-1207, were collected to assess the differences between group and individual work. The individual reviews discussed the Watson book, The Double Helix. Although some were very detailed and brought up specific questions of personality and group dynamics, the students seemed to not fully grasp the psycho-sociology aspect of the book until the case was analyzed in those terms in class. Comments regarding how science supposedly functions in a dispassionate, objective manner and how Watson presented it in a very different light, as competitive and personal, were noted. Some people saw it as his fault it took on this flavor. To them, his behavior seemed scandalously unscientific and even unethical at times. Personal criticisms of Watson came up repeatedly.

The book themes are discussed very narrowly and focus on whether this event is typical of science. The accounts are detailed enough to be of acceptable quality. However, when compared with the group reviews, it is clear that the team efforts were generally superior and the average grade of the reports went up as a result. The books were approached from a number of view points in the team reviews, and were better developed, adding to full comprehension. The group reviews were clearly approached differently than the individual assignment.

One important difference could be situational. The second account of the DNA discovery lends itself to comparative commentary. So, reading a different view of the same DNA case is probably a factor, but mainly the difference in perspective of the group assignment is probably due to the fact that each group had diverging psychological types. The class gained experience discussing personality differences based on the first book in class, and everyone had gotten their personal MBTI feedback. Thus, the teams approached the second book review in a deeper way. This led to extraordinary improvement of the reviews as the psycho-socio aspect of the book is taken into consideration.

In addition, the teams also got Rosalind Franklin's side of the story in this second account by Maddox, and moved on from personality into cultural and gender issues raised by this account. The richer mix of material that the teams had to work with would have been expected to improve the reviews. By now they were also learning about cognitive style as well, and getting their own feedback on a second cognitive measure, so the Watson-Crick collaboration was recognized as being based on contrasting cognitive styles with similar personalities by the time the second review is done. The Wilkins-Franklin clash which is explored by Maddox begs for comparable attention and seems to involve similar cognitive styles and nearly opposite personalities. However, Maddox tries to explain the clash in a different way, complicating their task. Since they were dealing with contrasting personalities in their own team, and finding the potential for complementarily and conflict in them as part of their group work, the analysis of a team that was not able to manage its internal cognitive diversity made for a rich learning experience. Though the Maddox book was not considered as good a read as the Watson book by most of the class, they praised its relative objectivity.

Feedback

The original layout for STS1207 included some group work based upon personality and MBTI personality grouping. Feedback from the D-07 course was collected, regarding group work intensity, and actual method of grouping. It was received from 21 of the 30 students – gathered after the first major group case study was carried out. Over 75 percent of the responding class members understood the significance of method of grouping. They saw how the problems were approached differently, how the personalities related to style and quality of work, and how the problem of communication was complicated by these differences. The students were told in class that the differences could increase potential conflict, but if managed correctly the quality of work was expected to be higher than would be produced by type-alike groups.

Therefore, it was clear that these students understood that the groups were designed to expose the individual to a known type of cognitive diversity to learn how to deal with the conflict potential that opposing types bring to a group. What annoys the students of different psychological type becomes evident, but it was also implied by the description of the 16 types distributed to the class. Over 60 percent of the class appreciated the high proportion of group activity in the class. Interestingly, one student mentioned that rather than opposite personality types, they would have preferred groups based on compatible, similar personalities. This student also questioned whether the diversity in these assigned groups had affected their overall performance and grade. Concerns about conflict are understandable, especially for feeling types. However, the evidence suggests that diversity in groups enhances performance.

Only 4 students did not appreciate the emphasis on group work - mainly due to the fact that the predictable problems that arose were not seen as part of a self study and practice in dealing with opposite personality types, but as being assigned to a 'bad' group. The biggest complaint was communication within the groups. Attendance and participation of other group members was an

issue for one student. Another student thought that the impersonal nature of the group was an issue, saying that the personalities did not make a difference since they were all strangers and thus interacted politely. The biggest complaint from almost all the students when questioned at the midterm was that the amount of group work before the exam was not enough to bring out the personality differences.

The new experimental course - STS120X takes this slow start on group work into consideration and incorporates weekly group assignments from the start. This is accompanied by a quick MBTI assessment process and feedback questionnaires. The method of grouping was kept the same, since the reasoning behind the group dynamics once understood, was informative.

The Midterm exam made it clear that cognitive diversity was helpful to the teams. Also, the type which was the disproportionate contributor for group works in that testing environment is evident, and can be taken into account for team formation. Of the ten teams, the biggest contributor turned out to be the Integrator type, identifiable using the GCSI cognitive indicator. Only one group, whose grade was ranging in middle of the list, had as their biggest contributor a Problem Solver. When considering the MBTI types, the students who are most likely to be the main contributors (7 out of 10) are ISTJ. They are the ones expected to do the work day by day and remember specific details.

The major group Laboratory experiment, designed for the B07 course was tested on the D07 course. Each of the small teams was assigned to be part of larger "lab" groups of 10 or 11 people each. They were asked to develop a plan on how to grow potatoes on the Moon (See Appendix A). Of the 24 students questioned, 16 of them appreciated the problem, and said it was an interesting and challenging project. The 8 students who did not like the project seemed to have been lost during the group work; either due to technicality of the subject, and due to lack of interest in group work itself.

A few major issues were brought up, including the issue of time. The students took the project to greater levels of technical detail than expected, doing extra research, bringing in subject matter from other classes and taking an overall engineering/scientific mindset to the problem. One group had brainstormed ideas over night, and met with each other to see the different ideas presented, and came up with a solution overnight. Another group communicated solely through email, and actually only a few members of the 'lab' were involved and avoided meetings.

Each lab team had equal numbers of Intuitives, and the other types were as equally distributed as possible. Although the lab groups took into consideration that each student within the lab approached the problem differently, the class did not really seem to understand the social network aspect of the experiment. The specific subject at hand was taken very literally and seriously.

Lunar Agriculture was a problem that seemed to capture the imagination of a few class members who came up with intense, technical solutions. On one team the leaders were biologically based. They were chemically based on another team and more mixed on the third. That meant that certain students were unable to contribute due to differences in major areas of study being stressed by a lab team.

These issues were taken into consideration, and the revised project for next year explicitly states that they should pay more attention to how their group functions, and how to cooperatively develop a plan that draws on the total pool of expertise and gives equal time to background research and presentation issues. More emphasis on social networks involving other groups - and everyone on each of the teams having the starter information (so as to activate the psycho-social aspects of the exercise) will be taken in consideration for the B07 course mid-term project. This year only one part of the three section background information was given to each team to instigate friendly competition, and to show how answers varied based on incomplete information. The experiment is

promising; however there should be more attention to the details of execution, which will be the case next year.

Discussion

Ideally, freshmen seminars offer first year students an introduction to the college environment. They provide a basic taste of what the higher education is like, and an opportunity to meet members of their class, which extends the social atmosphere that a college has to offer.[24] Interaction is important for the incoming freshmen because they are entering a setting radically different than their previous experience, and would benefit from guidance in developing their skills and establishing a sense of professionalism in their work. Seminars bring the student from a naive, traditional approach to learning that they gain from primary and secondary school, to a more independent, research oriented, fast paced learning method. Seminars that incorporate increased group work provide critical interaction which will help create relationships, and an understanding of each other's working style. An understanding of group dynamics is important to flourishing in the WPI curriculum.

WPI's competitor schools offer a variety of seminars, introducing the freshmen to campus life and research at the university. The course topics from many of the seminars deal with current issues regarding society and global development. The colleges and universities discussed below require first year students to take at least one freshmen seminar in addition to courses in their major area of coursework. Yale University, Dartmouth College and the Massachusetts Institute of Technology (MIT) offer seminars which students take and earn course credit in different departments. Yale University offers courses with enrollment exclusively for freshmen in a wide range of subjects.[25] The subject matter includes investigations of current issues via independent research and readings from scientific journals, newspapers, etc. Dartmouth College offers similar seminars on topics ranging from nanoparticles to tensions in the Middle East. An example of their freshmen course expectations would be the requirement of students to apply theories and

[24] Budny, Dan. Integrating the Freshmen Seminar and the Freshmen Problem Solving Courses. *Frontiers in Education.* 2005

philosophies on ecopsychology to their own experiences regarding environmental situations.[26] MIT has an interesting program for freshmen; seminars relating specifically to residence and campus life, as well as seminars on non-resident topics. Residence and campus life seminars discuss city life in Boston and surrounding areas, where as the non-resident topics include the environmental debate, third world economics and development of global infrastructure. The students are encouraged to take either type, and credit is distributed through departments and is considered a free elective.[27]

The STS-1207 course - Introduction to the Psycho-Sociology of Science - is a good course to turn into a freshmen seminar on at WPI. The course theme focuses on how personality types and cognitive styles influence scientific discovery accomplishment and career success. In addition, another topic discussed in this course is the responsibility of scientists to have a concern for public welfare and devote themselves to social improvement and public safety. The course incorporates a lot of group work, requiring the students to participate in independent group activities in and outside of the class time.

By grouping the students according to opposing personality types, it teaches the students to recognize group dynamics problems and communication with people different from themselves. Although it is not emphasized in the course, they are likely to learn how to alleviate the problems by learning how to work with different personalities, which is a necessity once the students start their careers in most fields. This exposure to MBTI personality types and the related encounter with group dynamics reflecting these differences will help the students complete their future group projects; especially the Sufficiency, the IQP, and the MQP. The course topic on scientific discovery would directly relate to the focus of a WPI education, science and engineering,

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[25] Yale University Course Catalog 2005-2006 school year.
[26] Dartmouth College Course catalog. 2005-2006 school years.
[27] Massachusetts Institute of Technology Course Catalog. 2005-2006 school years.

and would enhance it with the social aspect of discovery. This topic is brought out by the group projects, especially the lunar agriculture laboratory experiment discussed earlier.

Conclusion

If all goes well, the pilot run of the proposed Freshmen Seminar course will be during B term 2007. The course, although preferably for freshmen only, may have to be offered this first time so as to include upperclassmen, since it is still listed as STS-1207. Depending on class size and enrollment restrictions (since it is not yet approved as a 'Freshmen Seminar' and the Dean of The Freshmen Year Experience has yet to see a full description of it) it may be offered in two sections, one solely for freshmen. The course will probably be an experimental course for next year, and hopefully after assessment of the course it may be considered one possibility for a future freshmen seminar.

If possible, professors offering B Term 2007 chemistry or biology courses will be informed of the plan for this course and urged to take what is going on into account as they plan their own courses. If there is a possibility for real collaboration of two professors offering concurrent courses that should become evident. The syllabus for this course should be sent to the professors before the start of the next academic year, to see if the idea of collaboration appeals to them. Observation and analysis of the pilot run should conclusively reveal whether this course does indeed meet the goals of a freshmen seminar.

So far, the feedback from the D07 STS-1207 course reveals that the students have grasped the concept of personality typing and its affects on group dynamics. The students recognized certain diversity issues immediately. As conflicts involving communication began to develop, they responded with techniques to avoid or overcome them. The student team's book reviews were more developed and related to the subject matter taught in the course much better than the individual book reviews. Certain cognitive styles did appear to emerge as the major contributors in some task environments; however more feedback on group activity is needed to fully evaluate the situation. As the task environment changes so too should the main contributors. More emphasis on

group activity early in the course will be able to bring out personality differences, and the in-class discussions facilitated by group members will help to develop social skills and work ethic by the students.

Future evaluation of the course should provide the information necessary to fine tune the course and projects, and by the end, if it becomes established as a freshman seminar we think it will be a very successful one. The course topics readily coincide with certain courses taught at WPI, and the overall information taught is in agreement with the science and technology based curriculum at WPI. This Freshmen Seminar encompasses every point which other universities try to bring to their own incoming class seminars. It is an introduction to campus academic activity; the expectation associated with professional work, and a communication skills course which involves a solid understanding of social workings of teams and learning styles. It also provides valuable information developed through group inquiry while they develop skills that are the basis for future success.

Appendix

New Syllabus

B Term '07 - Oct23-Dec13

Tuesday October 23, 2007
Introduction to Course:
- Go over syllabus
- Pass out MBTI and Question Supplement (Return as Homework Assignment for Thursday).

Thursday October 25, 2007
Discussion of Science:
- Introduce Merton and Kuhn - background information – NOT their theories!
- In class discussion on how the Kuhnian Revolution changed the prevailing notion of The Nature of Science
- Collect MBTI
- Assign Merton and Kuhn Readings and questions: DUE Tuesday.

Friday October 26, 2007
Merton
- Discuss Science Reward Structure and Merton article on 'Puritan Spur to Science'
- Collect Questions from Reading
- Continue READINGS!

Monday October 29, 2007
MBTI Feedback, Verification – Form Teams
- Pass Back Results for their tests
- Explain Feedback and discuss how this can be used for Group Dynamics (whole class discussion)
- Introduction of Paradigms and Normal Science, Anomalies and "Crises"; Start discussions on Paradigm theory and what it is, why it is controversial

Tuesday October 30, 2007
FIRST GROUP ACTIVITY!
- Assign group based upon MBTI results
- Group Assignment - Describe a Leaf.
- In class questions collected - feedback from first group activity
- Description on the difference between a Book Review and a Book Report
- Continue Reading WATSON BOOK

Thursday November 1, 2007

Merton

- Discuss article on Priority Disputes by Merton
- Recommended Readings for today: Mitroff article on "Norms and Counter-Norms in Science"

Friday November 2, 2007

Anomalies and Discoveries

- Discussion on Anomalies
- Compare Kuhn and Merton
- Take the GCSI test
- Assign Watson book The Double Helix, Book Report Due Thursday November 8th.

Monday November 5, 2007

Emergence of a Psycho-Sociology of Science out of the Sociology of Science

- Read Niches and Strata article by Wilkes on Cognitive Style as measured by the GCSI
- Begin Discussion on articles and differences between MBTI and GCSI

Tuesday November 6, 2007

Continuation of GCSI Discussion and Introduction of the Phage Group

- Introduce major scientists - Delbruck, Luria, Pauling, Chase, etc.
- Touch upon the interdisciplinary beginnings of science via physicists entering the biology world.
- Continue Watson Book
- Recommended reading for today: Mullins article on the Phage Group

Thursday November 8, 2007

Discussion of Watson's point of view

- What happened and what issues does it raise
- Talk about paradigm state of the field at the outset of the book and why do you think Watson wrote it
- How does this tie in with Merton's and Kuhn's theories
- Collect Individual Book Review

Friday November 9, 2007

Continue Discussion of Watson

- Was this an internalist or externalist treatment of science?
- Discuss Watson/Crick and Franklin/Wilkins Relationships with personalities based on MBTI and GCSI
- Homework - Einstein-Russell Manifesto Reading

Monday November 12, 2007
Pugwash Discussions
- Introduce Linus Pauling, Einstein-Russell Manifesto
- Talk about Lewis Feuer article "Scientific Intellectual" and discuss the Manhattan Project
- Assign Maddox, Judson and Hoagland accounts for Group Book Report and Presentation

Tuesday November 13, 2007
More Pugwash
- Modern Day issues regarding Pugwash - Biological Weapons - Integrity in Science
- Discuss Student participation

Thursday November 15, 2007
Review for Midterm

Friday November 16, 2007
MIDTERM EXAM

Monday November 19, 2007
Discussion on the Origins of the Moon
- Apollo Moon Scientists

Tuesday November 20, 2007
Continue Discussions of Apollo Moon scientists

THANKSGIVING BREAK

Monday November 26, 2007
Begin Lab Experiment - Large Groups
- All groups will compete

Tuesday November 27, 2007
Large Lab Group Presentations
- Each Lab will present and defend their solution - 10-15 minutes each
- Turn in Solution Report

Thursday November 29, 2007
Discussions of how Cognitive and Personality Styles incline scientists to be less involved with social responsibility

Friday November 30, 2007
Continue discussions about personality and scientists' involvement with social responsibility

Monday December 3, 2007
Group Presentations - Comparing Watson's account with other account
- Discuss the personality differences from each account

Tuesday December 4, 2007
Group Presentations - Comparing Watson's account with other account
- Discuss the personality differences from each account

Thursday December 6, 2007
Nobel Prize Debate
- Assign DVD on Space Weapons for each team to watch for hw

Friday December 7, 2007
Space Weapon Debate
- Done in accordance with the Pugwash Style

Monday December 10, 2007
Group Activity Analysis
- Hand out questionnaire on Group Activities
- Discuss how personalities have affected group work; what they have learned to prevent problems
- Course/Teacher Evaluation

Tuesday December 11, 2007
Review for Final Exam

Thursday December 13, 2007
FINAL EXAM

MIDTERM PROJECT OUTLINE:

Project theme: Devise an elegant plan for growing potatoes on the Moon

Expected Class size: 30 students

Students will be broken into three groups. Same number of remote associations in each group. (Intuitive)

Group names: University of Maryland, Johnson Space Flight Center in Florida, and UK space science center. (This is to mirror each of the three labs involved with DNA structure discovery, King's College, Cavendish, and Linus Pauling's lab in California). Each student will be assigned not a character role to play, but a status within the Lab, meaning one will be the director of the lab, one is chief scientist, junior scientist, etc. Each of the three labs will be specialized in one of three subjects: Soil, Solar Energy, and Gas Exchange.

When the project is assigned, each group will receive a briefing paper on group lab's specialty, and a description on what their plan was.

Goal of the project:

With information sheet given, each group is to design a plan to grow potatoes on the moon. The group with the most elegantly designed plan, with each component for growing moon potatoes taken into consideration, i.e. solar energy, gas exchange, and soil, will earn an A- to an A. The second best plan will earn a B to a B+, and the third a B- to a C+. This project encourages friendly competition between groups. It is wrong to overtly steal papers or sources - such acts will be penalized. However, obtaining information via friendly chats and discussion between one member of each team, on or off the record is considered to be acceptable. Also, if it is observed that one member of another group is not treated equally, or underappreciated by their peers, it is appropriate to recruit that member into your group. If groups decide to pool information together and come up with one plan, all students will receive a B- to a B for their group grade.

* What is being studied from project point of view: social relationships between people in different groups and the flow of information; how people solve the problem with partial information; if there is open information sharing, the problem becomes easier to be solved, but no prize, however if everyone competes, the problem is harder to solve, takes slower, but in the end there is credit and fame to the winner. Also being studied: spy vs. network - if a friends share work (in different groups), and see how the network develops.

Leaf Activity

Before you is a leaf. You will have several minutes to write down below as many things that come to mind as you behold the leaf:

Now gather into your groups and chose the best three observations derived from the leaf out everyone's answers to present to the class.

1._____

2._____

3._____

What are the MBTI types of your group members?

Did one type tend to come up with a certain kind of answer, for example did they lean towards the physical description of the leaf or rather it's function?

Based on what you know about the different types, does this make sense?

Do you think it would be correct to assume how someone will think based on their MBTI results?