Class Assignments

- Personal profiles
  - Good job on introductions; good to learn about student history and motivations
- Library citations
  - Good overall (>80% accurate), but a few mistakes

- Questions to consider
  - What was your criteria for choosing a citation?
  - Did you read all abstracts?
  - Can you be sure the articles fit the topic from the abstract?

Biological Control of Plant Diseases

The Science of Biocontrol

Week 2

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Week	Lecture Topic	Question of the week	Written Assignment
1	Course Overview	Why are you here?	Recent reviews
2	The Science of BC	What do we need to learn?	New methods in biological control research
3	Tools and Evidence	What can we know?	Diversity and ecology of biocontrol microbes
4	Diversity and Ecology	How can we manage plant-associated microbesl?	Role of enzymes, antibiotics, or hyperparasitism
5	Direct Antagonism	How much antibiotic is produced or needed?	Induced resistance mechanisms
6	Indirect Antagonism	How does a plant integrate mutliple signals?	Soilborne disease suppression by cover crops
7	Soilborne Disease Control	What is the relative importance of abiotic vs biotic factors?	Foliar disease suppression by biochemical approach
8	Foliar Disease Control	Which diseases are best controlled?	Postharvest disease control on tomato or pepper
9	Post Harvest Disease Control	How does post-harvest differ?	New biopesticidelal active ingredients.
10	Commercial Development of Microbial and Biochemical Pesticides	What is needed to develop a BCA?	Product registration rules and tools
11	Regulation and Risk Assessment of Biopesticides	What should we regulate and how?	Use of biocontrols on tomato or pepper
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The Nature of Science

Western Scientific History and Philosophy

- History
  - Observation and Experimentation
    - Ancient Greeks (and others)
    - Categorized and cataloguing natural phenomena
    - Formalized theories that underlie science, including logic, experientialism and empiricism
  - Scientific Revolutions since the 1600s
    - Prediction from *expanded* observation of the heavens
    - Use of mathematics to *accurately quantify* and predict natural phenomena
    - Use of published results to create new technologies

The Nature of Science

Western Scientific History and Philosophy

- History
  - Institutions of Science
    - Royal societies and gentleman scholars
      - 1660 The Royal Society of London founded
      - Anonymous peer review
      - 18th and 19th Century adventures
    - State-sponsored research
      - "Prizes" grants and contracts from earliest days
      - Proliferation of universities, corporations, and government labs from the 1850-1990s leads to as logarithmic increase in scientific knowledge
      - Goals: increase power and control in and among different states and cultures

Key features of modern research have a long history

The Nature of Science

How have humans been affected?

- Industrial revolutions born from science research
  - Chemistry:
    - Organic synthesis (Dyes, petroleum, fertilizers and pesticides)
    - Modern synthetics (plastics, semiconductors, ceramics, nanotechnologies)
  - Engineering:
    - Military hardware (guns, bombs, boats, and more)
    - Power systems (steam, diesel, hydro, methane, and more)
    - Civil machinery (factories, refrigeration, transportation, communication/entertainment)
  - Physics:
    - Time keeping and navigation (clocks, maps, radar, GPS)
    - Information technology (telephones, lasers, computers, networks)
    - Medical technology (imaging technologies, surgical tools)

The Nature of Science

How have humans been affected?

- Industrial revolutions born from science research
  - Biology
    - Improved agriculture (hybrid crops, improved cultural practices, plant breeding and transgenic crops, microbial and biochemical biopesticides)
    - Greater health (vitamins, antibiotics other therapeutics, vaccines, sewage treatment, disease diagnosis, monitoring, and communication)
    - More energy and manufacturing options (ethanol, biodiesel, anaerobic digestion, biosynthetics)

Science provides options and opportunities for societies to improve their quality of life

The Nature of Science

Western Scientific History and Philosophy

- Philosophy
  - Empiricism
    - One theory of knowledge
    - Asserts that knowledge arises form experience
    - Emphasizes experience and evidence (both filtered through our senses)
    - Uses experimentation to guide development of knowledge
  - Rationalism
    - Complementary theory of knowledge
    - Asserts that truth is not sensory but intellectual and deductive
    - Uses math and Gedanken / “thought experiments” to generate hypotheses and theories

The Nature of Science

Western Scientific History and Philosophy

- Philosophy
  - Inductive reasoning
    - One form of reasoning
    - Moving from specific facts to a general conclusion
    - Indicate a degree of support (probability) for the conclusion
  - Deductive and abductive reasoning
    - Complement inductive reasoning
    - Used to generate hypotheses (abductive)
    - Used to fill in the gaps/details of knowledge (deductive)

Science primarily uses empiricism and inductive reasoning to generate facts and understanding about the universe we live in.

The Nature of Science

The Limits and Potential of Science

- Science focuses on the external world, therefore it does not encompass many philosophies of mind
  - Psychology, psychiatry, and neuroscience try to bridge the gap in some ways.
- Other significant philosophies and ways of thinking exist
  - Religion is divinitive and/or inspired and focuses on human relationships
  - Rationalism, Skepticism, Stoicism and Pragmatism all seek truth in various ways

The Nature of Science

The Limits and Potential of Science

- Only science has led to the greatest variation in approaches to control the external world
  - Scientific results and conclusions can be verified by others regardless of location or mindset
  - Science leads to new questions and directions of thought and action
  - Scientific results are the basis for new technologies

While not the only useful means to discover truth and improve the human condition, Science is special human construct that has led to substantial changes in how we live in our world.

The Nature of Science

The Progress of Science

- Normal and Revolutionary Science
  - Key reference: Thomas Kuhn (1962) *The Structure of Scientific Revolutions*
  - Normal science is based on “paradigms” (overarching concepts and methods that constrain what can be known) generated by revolutionary science
- Normal science is…
  - Characterized by general agreement on key questions and approaches to answer them
  - Well organized in terms of effort
- Normal science least to theories that are…
  - Theories are evidence-based inductive constructs
  - Theories are chosen based on 5 criteria:

    Accurate, consistent, broad scope, simple, fruitful

The Nature of Science

The Progress of Science

- Normal science can lead to crises
  - New techniques or approaches sometimes lead to unexpected observations
  - Unexpected observations slowly accumulate
- Crisis Science
  - Repeated observations and experiments challenge the prevailing paradigm and efforts become disorganized
  - Politics and personality affect how the crises are handled
- Revolutionary science
  - provides new syntheses of all available observations
  - Generates new paradigms that have the characteristics of good theories
  - New paradigms are “incommensurable” with the old ones; present a completely different understanding

The Nature of Science

The Progress of Science

- Three main approaches to science
  - Observational
    - Hypotheses are few and underdeveloped
    - New techniques are used to generate data
  - Empirical
    - Specific hypotheses are formulated and tested
    - Controls are used to determine the effects of one or more other variables
    - Alternative explanations are considered and refuted by experiment or reason
  - Technological
    - Results of observational and empirical studies used to generate useful tools or processes

Human understanding and the focus of science changes over time.

The Nature of Science

Modern Science

- General practice (beyond the Scientific Method)
  - Background reading
  - Question identification
  - Hypothesis generation
  - Method selection
  - Fund acquisition and management
  - Personnel and equipment management
  - Observation and/or experimentation
  - Data collection and analysis
  - Synthesis
  - Presentation and critique
  - Publication

The Nature of Science

Modern Science

- Social structures
  - Individuals and like-minded groups
    - Natural curiosity and desire to discover
    - Often motivated by need for recognition
  - Laboratories
    - Provide resources for primary investigations
    - Primary operating unit for generation of publications
  - Departments
    - Provide discipline-related resources and training
    - Educate young people in a scientific disciplines

The Nature of Science

Modern Science

- Social structures continued…
  - Institutions (Universities, Corporations, Government Labs)
    - Provide infrastructure for conducting science
    - Link scientists to the rest of society Professional societies and publishers
  - Professional societies and publishers
    - Provide outlets for presentation
    - Reinforce standards of professionalism
    - Provide communities for scientists structured around disciplines and/or topics of investigation

Science is an ongoing and dynamic human activity with many levels of engagement.

Biological Control Science

What is it?

- Subfield within the life sciences
  - Typically studied in institutions with agricultural focus
  - Primary research conducted within entomology and plant pathology, though examples in other Departments do occur
  - Social constructs include
    - The International Organization for Biological Control (founded in 1955)
    - Numerous subcultures / committees within larger conferences such as BioKorea and professional societies such as the Korean Society of Plant Pathology and the American Phytopathological Society

This course will focus on biocontrol of plant pathogens and the promotion of plant health

Biological Control Science

What is it?

- Initial observations
  - Initial descriptions in the late 1920s and early 1930's by several groups
  - Early researchers identified potential for use in controlling pests in agriculture
  - Early work identified antibiosis, competition, and parasitism as mechanisms
  - Work in the 1980s introduced concept of induced systemic resistance as additional mechanism of action

The evolving theories and practices of biocontrol are over 80 years old.

Biological Control Science

What is it?

- The paradigm of biological control as it relates to plant diseases
  - Pathogens can be suppressed by the actions of one or more soil- or plant-associated microorganism.
  - Like pathogens, natural antagonists, also called biocontrol agents (BCA), occur in all agricultural systems, though to varying degrees and are affected by environmental conditions
  - BCAs act to limit pathogen populations or activities by four key mechanisms: antibiosis, competition, parasitism, and the induction of plant host resistance

This paradigm underlies all research related to biological control

Biological Control Science

Current Status

- Publications
  - Three peer-reviewed journals: BioControl, Biological Control, Biocontrol Science and Technology
  - Plant Diseases Management Reports provide data of efficacy trials
  - Articles published in many other periodicals (e.g. Annual Review of Phytopathology, Phytopathology, Applied and Environmental Microbiology)
  - Specialty books released every few years

There are many academic sources of information on biocontrol

Biological Control Science

Current Status

- Normal research questions (BCA focus)
  - Which microbes have biocontrol activities?
    - Isolate and identify / Identify and isolate
  - Where do BCA occur?
    - Detect and link to conditions of place
  - When are BCA most likely to prevent disease?
    - Apply or observe and associate with environmental variables
  - How do BCA act to suppress pathogens?
    - Characterize components and activities *in vitro* and *in situ*
- Note: Questions focusing on host and pathogen status are variations on the above.

Most biocontrol researchers are doing normal science

Biological Control Science

Is there a crisis?

- Most candidate BCA do not work reliably *in situ*
- Few novel BCA genera have been discovered in the last 30 years
- Genome sequences of BCA reveal multiple capacities to exert suppression
- Studies of active metabolites (such as DAPG) and strains that produce them reveal multiple capacities to alter the ecology of plant health status
- Few BCA commercialized prior to 2001, but now regulatory agencies are swamped with applications for new active biopesticide ingredients

Biocontrol science displays some facets of crisis science, but what would the new paradigm be?

Biological Control Science

What do we need to learn? General questions.

- Which microbes are contributing to biocontrol under various conditions?
- To what degree do BCA alter host physiology?
- Can we enhance biocontrol through modifications of the abiotic environment, host, or BCA populations?
- By what molecular and ecological mechanisms do BCA control disease?
- What are the risks of applying biocontrols and how do we manage those risks effectively?
- How can we integrate biocontrol most effectively into different agricultural systems?

Biological Control Science

What do we need to learn? Specific topics and questions.

- The diversity and ecology of plant- and pathogen-associated microbes
  - Which members of microbial communities have biocontrol potential?
  - How are BCA distributed in the environment relative to hosts, pathogens, and other community members?
  - How much variation is there in BCA populations?
- The activities of BCA alone and in context
  - What genes and gene products are essential for biocontrol?
  - How are such genes regulated in time and space?
  - How does plant host genotype affect BCA activity and expression?
- Practical integration
  - Which production systems might rely heavily on biocontrol? Why?
  - Can cost-effective formulations be developed for any given BCA?
  - Are microbial or biochemical approaches most useful?
  - What is the relative value of different BCA and chemical standards?

There is much exciting research still be to be done.

What defines "good quality" science?

- Validity
  - Conclusions are confirmable
    - No reasonable alternative hypotheses
  - Results are reproducible
    - Same or another research can observe the same result using the same methods
- Novelty
  - Experiments reveal new insight into experimental system
  - Methods are freshly applied to the systems

Projects and papers may have one or both characteristics

What defines “good quality” in biocontrol science?

- Validity
  - The biocontrol component is the primary driver of improved plant health
  - Disease suppression is reproducible by others with the same materials or methods at other location
- Novelty
  - No “similar” observation, explanation, or phenomenon has been previously reported
  - No previous use of the technique in the biocontrol field

Experts in the field decide collectively on the standards applied and these change over time

Take Home Messages (THM)

- Biocontrol is a highly specialized subject (within plant pathology)
  - Focuses on questions related to pest management
  - Process is studied on molecular, cellular, physiological, ecological, and economic levels
- More broadly, science is special
  - more than just methods and results
  - aspires to generate true and useful knowledge
  - gives people options to organize and manage their world.

Take Home Messages (THM)

- What do we need to learn about biocontrol?
  - Theories and experiments that form our view of biocontrol today
  - Example technological successes (and failures) and how they became a reality
  - Identify unanswered questions and approaches to expanding our knowledge

- Next lecture
  - Tools and Evidence: What can we know and learn about biological control?

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Week 2 Class Assignments

- Topic: **New methods in biological control research**
  - Paper may cover any description or application of a molecular or biochemical method to biocontrol or disease suppression in last 5 years
  - Possible search terms: DNA, RNA, qPCR, TRFLP, ARISA, OFRG, BOX PCR, AFLP, GFP, YFP, HPLC, NMR, gas chromatography, mass spectroscopy, transcriptional fusion, molecular fingerprinting, genome sequence, pyrosequencing, genomics, proteomics, metabolomics, metagenomics…
  - Method *must be used* to learn something about biocontrol organisms or suppression of plant pathogens in some way

Week 2 Class Assignments

- Reminder of the structure of the assignment
  - Literature search and abstract reading (20)
  - Paper selection and "rating" (**3 in bold**)
  - Paper Critique (select 1)
    - Copy citation and abstract
    - 2-4 sentences describing *novelty* of the work
    - 2-4 sentences describing the *validity* of the work
  - Submitting the assignment
    - Due by Friday noon
    - Send via e-mail to me **as .doc format (Word 2007 or earlier)**
    - **Name file: LastName_FirstName_Wk2.doc**