War and Uncertainty

Science and War

- Mid-1900's – Newtonian physics – axioms – replaced by probability
- Absolute time/space?
- Observations - relative position
- Biology – statistics –populations – field observations

- Also – science for mass warfare

- Enormous enterprise – infrastructure/labour
- War – search for relative vs absolute

Mendel and Evolution

- 1800's – biology – field observation/classification/anatomy
- Lab research – experimental approach
- Possible?
- New tool – microscopes/cell-staining methods, x-rays, crystallography
- Tools/techniques – chemistry and physics – modern cellular biology
- Combined with statistics (math) - "new synthesis"

“…a powerful new model of evolution by folding the microbiology and chemistry of genetics into the macrobiology of natural selection.” (Ede and Cormack, 300)

Mendel and Evolution

- Lack of support for natural selection from biologists – issue of inheritance

- Experimentation/lab work – cellular level

Mendel and Plant-Breeding

- Understand evolution - look to the cell
- Problem – link cellular events – to macrobiological result
- Johann Gregor Mendel (1822–84)
- Plant breeding experiment
- Over 28,000 pea plants
- Seven characteristics – two forms
- Generation to generation
- Cross-breeding of plants
- Traits – discrete – did not blend

Mendel and Plant-Breeding

- Characteristics – dominant/recessive
- Two key concepts: law of segregation, law of independent assortment
- Reception - lack of impact
- Method – "…for predicting how characteristics were distributed in a population over multiple generations." (Ede and Cormack, 302)
- Sexual reproduction -1/2 matter for new organism
- However –1900- rediscovery:
- Hugo de Vries (1848–1935)
- C.E. Correns (1864–1935)
- E. von Tschermak (1871–1962)

Mendel and Plant-Breeding

- De Vries – unit characteristics of heredity – pangens
- “mutations” – new characteristics
- Walter Sutton (1877–1916) - The Chromosomes Theory of Heredity – “…genes are carried by chromosomes and that each egg or sperm cell contains only half of the chromosome pair.” (Ede and Cormack, 303)
- Heinrich Wilhelm von Waldeyer-Hartz (1836–1912)
- Greek word – colour, body
- Tools - 1956 – 46 chromosomes
- Discovery of genes

Science and War

- Britain – Germany – 1st modern arms race
- Imperial policy – society
- Germany – lack of resources, high cost – science and technology
- Integrated system – schools, universities, industry, government, scientists
- Education – foundation – literacy, trained scientists
- Link – government, business, academic research
- Government – fund education, research institutions
- Research institutions, universities – problems of importance
- Topics – industrial applications

The Chemists' War

- Example of intersection?
- Fritz Haber (1868–1934) and Carl Bosch (1874–1940)
- Rise in population required – fertilizer solution
- Haber-Bosch system – low-cost ammonia – large quantities
- Nobel Prize – synthesis of ammonia
- Oppau and Leuna Ammonia Works – "…the first industrial producer of nitrate products that did not require large-scale electrical supplies to operate."
- 1934 – most fixed nitrogen – synthetically produced

The Chemists' War

- Initially – artificial fertilizer, ammonia for industry
- War – nitrates for explosives – Ammonia Works
- WW1 – Haber – chemical attack –chlorine gas
- 1915 – front line – Ypres, Belgium – 5000 dead, 15000 wounded
- Chlorine as a weapon – availability, weight
- With moisture – hydrochloric acid
- Changed war and also science
- Race- new chemicals – Allies – national research councils

The Chemists' War

- Chlorine – easy to recognize/defend
- Haber – phosgene – odourless, colourless - slower than chlorine
- Others used: chloropicrin, mustard gas, diphenylchlorarsine
- 1916 – chemicals – standard weapons
- Scientists – all aspects of war – aerial combat, sonar, radio communication

The Death of Certainty

- Post WW1 period – how nature worked – reconsideration
- What led to this?
- Nuclear physics – continued development (indeterminacy)
- Discovery of genetics, synthesis – evolution, biochemistry

- Nuclear physics – power, weapons
- Genetics – social, religious – challenged

Indeterminacy

- Start of 1900's – chemistry/physics – separate
- Physics – scientific subject
- Chemistry – atomic/molecular
- Physics – extreme ends – subatomic, structure of universe
- Classic physics – absolute, certainty of laws
- Observer's location? No difference
- New? Precise, contingent system
- Importance – condition of observer
- Example at basic level?

Indeterminacy

- “Uncertainty principle” Accurate?
- Probabilistic approach – more precise – system – more than a single state
- Indeterminacy - unsettling – conditions, existing at once
- Schrodinger’s cat – “…because we cannot know the state of the cat until we look, the cat is equally alive and dead at the same time since there is a 50/50 chance of either condition. Only by opening the diabolical device will the universe resolve into one state or the other.” (Ede and Cormack, 321)
- Act of observation- changes – observed
- Implications – social sciences
- Philosophical issues – unnoticeable – subatomic

Evolution, Cellular Biology and the New Synthesis

- Research – genes/inheritance – evolutionary theory
- Mendelians: "…populations could not have continuous variation and that evolution could happen only through mutation…" (Ede and Cormack, 322-323)
- Biometricians: "…populations varied around a mean and that the mean could be moved over time." (Ede and Cormack, 323)
- Population perspective – through use of statistics
- Two approaches – population studies and pure math
- Result – new synthesis

The New Synthesis

- R.A. Fisher (1890–1962) - mathematician, J.B.S. Haldane (1892–1964) - biochemist, Sewall Wright (1889–1988) –biologist
- Darwinism, Mendelism, statistics – biometry
- “By thinking in terms of populations rather than individuals, the new synthesis allowed for an integration of the geographical and species concerns of field naturalists with abstract mathematical population genetics.” (Ede and Cormack, 325)
- 1940’s – evolutionary process
- Functioning of genes? Tough – molecular level – nuclear components
- Cell – molecule soup – separation?
- Enzymes - Wilhelm Friedrich Kühne (1837–1900) – classification
- Cell activity
- 1900- identification

Reactions to Evolution

Social Darwinism and Eugenics

- Early reactions – Social Darwinism
- Selection, social hierarchy – race
- Eugenics: "…belief that certain people and certain groups of people had qualities that made them superior or inferior to the social norm and that by the control of reproduction the good qualities could be preserved and enhanced, while the bad qualities could be eliminated." (Ede and Cormack, 326-327)
- Founder – Francis Galton – term – social statistics, biometry
- Identification - differences – physical/intellectual – people/groups
- Sybil Gotto (1885–1955) – Eugenics Education Society – 1907
- Eugenics laws – around world – involuntary sterilization

The Atomic Bomb

- Rise of Fascism – Italy, Germany – escaped scientists –fearful – super weapon
- Radioactivity – research – difficult – material, contamination, work with
- Lise Meitner (1878–1968), Otto Hahn (1879–1968) – uranium bombardment
- Hahn, Fritz Strassmann (1902–80) – experiments – bombardment of uranium w/ neutrons – product? Barium
- Why? Meitner – uranium nucleus – split – "fission"
- Sensation – replication
- Leo Szilard (1898–1964) – nuclear bomb – neutron chain reaction – patent
- 1939 – WW2
- German - Congo – uranium
- 1940 - Werner Heisenberg - "On the Possibility of Technical Energy Production from Uranium Splitting"

The Atomic Bomb

- Szilard – American government
- Einstein letter to FDR
- Military consultation - Bohr, Fermi, von Neumann
- Office of Scientific Research and Development (OSRD)
- University research
- 1940 - $74 million to 1.59 billion

The Manhattan Project

- December 6, 1941 – authorized research
- Manhattan Engineering District
- Two issues:
- Supply – uranium
- Technical – material
- Oak Ridges, Tennessee – Uranium
- Glenn Seaborg (1912–99) – Plutonium
- Los Alamo, New Mexico – scientific team - technical/engineering
- Three bombs – two used – Hiroshima, Nagasaki, Japan

National Security and Science Policy

- Szilard – prediction – arms race
- Postwar-nuclear/national security - scientists – work for state
- Four countries –capacity
- WW2 – teams remained intact
- "Charged environment" -Cold War
- Next step – focus on fusion – H-Bomb

- 1955 – Einstein, Russell – give up nuclear arms, peaceful resolution of conflicts

Discovering DNA

- Post ww2 – genetics, cell biology
- Movement – population to structure of genetic material
- Avery/MacLeod, Hershey/Chase – DNA – genetic material
- Structure of DNA:
- Linus Pauling, Rosalind Franklin, Maurice Wilkins, Francis Crick, James Watson