

CHEM 151GS – Molecules that Changed the World Syllabus

Course description

This course follows the fascinating quest of molecules, their applications, and their societal impact. It will cover the basic science behind the development and application of key drugs, naturally occurring compounds, fuels, nutrients, etc. We will explore the ethical issues and social responsibilities of scientists at the intersection between scientific advancements and human justice.

We will cover 5 broad groups of molecules:

- the molecules of life
- the molecules of health
- the molecules of enjoyment
- the molecules of conflict
- the molecules that changed the world (choose your own molecule)

CHEM 40AB or CHEM 41AB are required prerequisites.

Examination and Grading

Discussion and participation – 4 points daily x 20 = 80 points

Weekly reflection writings – 10 points x 5 = 50 points

Game Changer Molecule presentation = 20 points

Game Changer Molecule Final paper = 50 points

Class total = 200 points

Guaranteed point cutoffs

≥180 points = A (+/- inclusive)

≥160 points = B (+/- inclusive)

≥140 points = C (+/- inclusive)

≥120 points = D

<120 points = F

Course letter grades will be an objective assessment of your individual performance, *i.e.* there are no predetermined number of A's, B's, or C's.

Lecture Structure

Each topic (numbered item below) follows a 2-day plan:

Prep – assigned reading (done out of class)

Day 1 – background presentation and facilitated scientific discussion

Day 2 – live research activity with the class; focusing on impacts to human aspects of the molecule(s) to construct a written summary of what the individual research discovered

*Excursion/outing days are built into the schedule along with flexibility for overflow discussion and research

The molecules of life (1 week)

1) Atmospheric chemistry – CO₂, O₂, and water

- a. *Reading:* <https://www.compoundchem.com/2017/01/18/ocean-acidification-co2/>
- b. *Reading:* <https://www.compoundchem.com/2015/10/21/rtc-week-2015-3-nitrogen-containing-atmospheric-pollutants/>
- c. *Reading:* <https://www.compoundchem.com/2015/05/05/atmospheric-pollutants/>

- d. Impacts to humanity: disproportionate burden of benefits and consequences across the globe, access to clean drinking water
- 2) Agricultural chemistry – fertilizers (ammonia and phosphate) and pesticides
 - a. *Reading:* <https://www.compoundchem.com/2015/04/14/neonicotinoids/>
 - b. *Reading:* <https://cen.acs.org/food/agriculture/Periodic-Graphics-elements-fertilizers/98/i11>
 - c. *Reading:* <https://www.compoundchem.com/2020/08/05/ammonium-nitrate/>
 - d. Impacts to humanity: access to food (food deserts and insecurity), access to land
 - i. **Excursion** to History of Science Museum in Oxford.

The molecules of health (1 week)

- 3) Antibiotic and antiviral drugs – penicillin and remdesivir
 - a. *Reading:* <https://www.compoundchem.com/2014/09/08/antibiotics/>
 - b. Impacts to humanity: the international collaboration effort of the 1940s to make synthetic penicillin (and failing) + COVID efforts to make available treatments; How and when should scientists consider who gets access to their breakthroughs? What role does and should the scientist have in scientific access?
 - i. **Excursion** to Fleming Lab Museum and Imperial War Museum in London. This excursion connects the discovery of penicillin (actually walk through the laboratory space where this invention occurred) to the global historical events that provided the push for industrial scale up and chemical synthesis (IWM highlights the human cost of WWII).
- 4) Contraceptives – progestogens and estrogens
 - a. *Reading:* <https://www.compoundchem.com/2015/02/03/oral-contraceptives/>
 - b. Impacts to humanity: who developed different iterations? Access and information? What is missing? Uninformed consent in Puerto Rico during development and trials

The molecules of enjoyment (1 week)

- 5) Alcohol
 - a. *Reading:* <https://www.science.org/content/article/ability-consume-alcohol-may-have-shaped-primate-evolution>
 - b. *Reading:* <https://www.compoundchem.com/2016/06/08/vodka/>
 - c. *Reading:* <https://www.compoundchem.com/2015/11/12/rum/>
 - d. Impacts to humanity: change of brewing from a domestic to commercial enterprise; role of alcohol in colonialization and human enslavement
- 6) Pain relievers – acetaminophen, opioids
 - a. *Reading:* <https://www.compoundchem.com/2014/09/25/painkillers/>
 - b. Impacts to humanity: how did societies decide which compounds were 'good' and which were 'bad'? What data was used to make those decisions? What is the role of pharma company/scientist on chemical dependency? What role do and should scientists play in making laws/rules/schedules of classified drugs? How did xenophobia and racism shape current US drug laws?
 - i. **Excursion** to GSK Stevenage R&D site. This excursion connects the structures and pharmaceutical impacts of the molecules discussed in this module to the human infrastructure that's required to develop them. The cost to develop pharmaceuticals can provide context to some of the 'impacts to humanity' prompts we will be discussing in this module.

The molecules of conflict (1.5 weeks)

7) Explosives and WMDs - TNT

- Reading: <https://www.compoundchem.com/category/chemical-warfare/>
- Reading: <https://www.compoundchem.com/2016/04/26/nuclear-reactors/>
- Impacts to humanity: the impact of developing and using nuclear weapons; Alfred Nobel and TNT. What responsibility do scientists who develop high-energy molecules have on the end uses of them? How should scientists weigh potential for good against potential to cause harm? Does it matter who is harmed and who does the harm?

8) Hydrocarbons – propane, butane, gasoline

- Reading: <https://www.compoundchem.com/2016/05/17/petrol/>
- Fisher-Tropsch and its role in WWII
- Impacts to humanity: burning fossil fuels contribution to climate change, global trade, Fisher-Tropsch and WWII scientific discoveries. Most large UK cities levy a 'congestion charge' on vehicles within the city boundaries to combat traffic-related negatives. How does this system compare to US car culture? How does public transportation access impact our local and global environments?
 - Excursion** to Imperial War Museum of London is directly connected to the molecules and discussion topics of this module and occurs earlier in the program.

9) Stimulants – caffeine and cocaine

- Reading: <https://www.compoundchem.com/2014/02/01/polyphenols-antioxidants-the-chemistry-of-tea/>
- Reading: <https://www.drugabuse.gov/publications/research-reports/cocaine/what-cocaine>
- Impacts to humanity: how did the drive for access to these stimulants shape our global community? How did we decide that caffeine derived from tea/coffee was a 'good' stimulant while cocaine derived from coca was a 'bad' one? Who benefited from the globalization of these goods being traded? Who suffered?
 - Excursion** to Afternoon high-tea. This is intended to expose students to the cultural traditional of tea drinking within the UK while considering how their perspectives on how stimulant containing commodities (like tea and coffee) shaped global trade.

The molecules that changed the world (0.5 week)

- Each student selects a molecule they want to dig deeper into their impact on the world and society, perform research, develop ~5 minute presentations, and write final paper on the selected molecule.

CHEM 151GS Course Schedule

MTWR 12pm-1:15pm

	(M)	(T)	(W)	(R)
Week 1	of Life	of Life	of Life	excursion
Week 2	of Health	of Health	of Health	excursion
Week 3	of Enjoyment	of Enjoyment	of Enjoyment	excursion
Week 4	of Conflict	of Conflict	of Conflict	excursion
Week 5	of Conflict	MtCtW research	Presentations	Presentations