Lecture 19: Intro to Literature & the Environment, *The Climate Crisis, What It Is*

CO2, Plants, & Carbs

Rising levels of atmospheric CO2 (carbon dioxide) are the principal cause of climate change.
Since Shakespeare's time, CO2 in the atmosphere has risen from 280 parts per million (PPM) to over 415PPM today.
Where did all that CO2 come from?

Although our atmosphere contains relatively small concentrations of CO2, it has a profound impact on plants, animals, and the climate.

Plants are capable of doing something altogether extraordinary with atmospheric CO2 when combined with H2O and energized by solar radiation.
Through the process of photosynthesis, molecules of CO2 and molecules of H2O are synthesized into a range of new molecules.

6 molecules of CO_2 + 6 molecules of H_2O becomes
1 molecule of $C_6H_{12}O_6$ (glucose)
and 6 molecules of O_2 (atmospheric oxygen)

This is a crucial service for all animals, because
1) Six molecules of CO2 are nicely converted to six molecules of O2.
2) One molecule of glucose (fructose, galactose) is also created, as are similar molecules, such as sucrose. These sugars/carbohydrates are essential foods for all animals.
The "carb" in the word "carbohydrates" comes from carbon, as carbohydrates are hydrates of carbon.

When life on earth is referred to as "carbon based" (as it often is in sci-fi, like the series Altered Carbon), it is an acknowledgment that carbon is an essential constituent of all plants and animals. The human body is 65% Oxygen, 18.5% Carbon, 9.5% Hydrogen.

Much of our world has been made out of thin air: carbon and oxygen (CO). For example,
Clothing made directly of plant material, like cotton, linen, hemp, etc, and indirectly from plants metabolized into animal products, such as leather, wool, silk, etc.
Food, either directly from plants, or from animals like cows that turn grass and soybeans into milk and meat.
Our homes and their furnishings, as many houses and pieces of furniture are principally made of wood.

Fossil Fuels

In addition to synthesizing sugars like glucose from CO2 and H2O by way of photosynthesis, plants can create other molecules, such as cellulose ($C_6H_{10}O_5$), hemicellulose, and lignin. Wood is chiefly composed of these three molecules.

When a plant dies and decays, the carbon that it contains (whether in the form of glucose, cellulose, lignin, etc) generally recombines with oxygen to again become atmospheric CO2.

Every Spring plants "spring" up with new growth and pull CO2 from the atmosphere. Each Fall sees the "fall" of decaying plant material to the ground where it releases CO2 back into the atmosphere. Hence, global CO2 levels go up slightly during our Winter and down in the Summer.
(This would be offset by the southern hemisphere, but 68% of the earth's land mass is in the northern hemisphere.)

Under certain circumstances, plant matter does not decay in the above way, which is via aerobic decomposition (i. e. in the presence of oxygen, which allows the carbon to again form CO2). Although relatively rare today (at least when the whole earth is taken into account), these conditions were quite common a few hundred million years ago, when the earth was far more swampy and in general watery (largely because there was little ice on the planet).

When plant matter falls under water, aerobic decomposition largely stops, as the decaying process becomes mostly anaerobic. Under these circumstances, carbon in the form of CO2 is not released back into the atmosphere, but is instead sequestered underwater and ultimately, under the right conditions, under ground.

After a few hundred million years of heat and pressure, plant and animal matter is fossilized into what we commonly call "fossil fuels," as molecules like glucose are transformed.
$C_6H_{12}O_6$ (glucose)
CH_4 (methane, which is the "natural gas" we cook & heat with)
$C_nH_{2n}O_2$ (basic formula for petroleum oil that makes gasoline)
$C_{240}H_{90}O_4$ NS (anthracite, the most energy rich form of coal)
Note that oil and coal can pick up nitrogen (N) and sulfur (S) during the fossilization process. When combined with oxygen during combustion, these produce oxides of nitrogen and sulfur dioxide, which are worrisome types of point-source pollution. Oxides of nitrogen can indirectly also act of greenhouse gases.

Greenhouse Gases

If you leave your car with its windows up in the sun on a comfortable 75 degree day, within 30 minutes the temperature in the car can rise to 109 degrees.
This is how a greenhouse, which traps solar radiation, works.
(It is also why you should never, ever leave your pets in a car on a sunny day with the windows up!)

When we talk about the "greenhouse effect," we are referencing how the earth's atmosphere (and certain gasses in particular) allow solar radiation to heat our planet in a consistent way.
Even though our atmosphere is an incredibly thin layer (a single layer of lacquer on a basketball would be proportionately thicker), it nonetheless keeps our planet warm.

CO2, methane, and other gases are called "greenhouse gases" because they all contribute to the greenhouse effect.
Greenhouse gases are not in themselves bad. Without them, earth would be too cold to be habitable.
However, because we have been pumping greenhouse gases into the atmosphere over the past 400 years (especially the past 60 years), our planet is quickly warming.

We initially referred to the impact that increased levels of greenhouse gases have on the planet as "global warming."
However, now that we realize that an increase in these atmospheric gases is changing our global climate in a range of ways, such as with more severe weather events (esp hurricanes and monsoons), more severe droughts, changes in regional weather patterns, etc., we refer to all this and global warming as "climate change."

Questioning when global warming or climate change is going to begin is misguided. It has already begun.
Since 1880, average global temperatures have risen around 1.8 degrees Fahrenheit.
Hence extreme weather events are now the norm.

CH_4 (methane - "natural gas" - gaseous fossil fuel)
$C_nH_{2n}O_2$ (basic formula for petroleum oil - liquid fossil fuel)
$C_{240}H_{90}O_4$ NS (anthracite, a form of coal - solid fossil fuel)
When methane, petroleum oil, or coal is burned, the carbon (C) that had been buried under ground for hundreds of millions of years - and hence safely sequestered- combines with oxygen to become CO2, the most common greenhouse gas. 4

Climate change is impacting the entire planet and all life on it.

No place on the face of the globe will be left untouched, from the upper limits of the atmosphere to the deepest ocean floors.
The next lecture will explore in detail how climate change is changing our planet and its life.

Plants and Animals

The earth has experienced five major extinction events where 75% or more of all animals on the planet died off in a relatively short period.
While most people are familiar with the fifth extinction event, which killed off dinosaurs 66 million years ago, #3 is of special interest in terms of climate change.

252 million years ago, the Permian–Triassic extinction event was caused by some sort of major eruption, perhaps a volcano.
Whatever the cause, increased CO2 levels quickly caused global temperature to rise by five degrees, which initiated a cascade of events, such as the rise of methane.

During the Permian–Triassic extinction event, 97% of all life on earth died. In comparison, "just" 75% of life on earth died during the Jurassic event that killed the dinosaurs.
Estimates suggest that we are currently adding CO2 to the atmosphere at least 10 times faster than happened during the Permian–Triassic extinction event.

As a consequence of this and other factors (such as habitat loss), experts suggest that we are now in the midst of our planet's sixth extinction event.
The 2014 book The Sixth Extinction: An Unnatural History by Elizabeth Kolbert, which won a Pulitzer Prize, is an excellent introduction to this issue.

The U.N. Convention on Biological Diversity estimates that: “Every day, up to 150 species are lost.” In other words, over 50,000 species are becoming extinct every year.
As Kolbert notes, this is perhaps 10,000 times the normal rate of extinction.

Although the extinction rate is itself disturbing, it only tells part of the story, as the overall number of extant animals on the planet has been dramatically reduced by human action

All the wild mammals, birds, reptiles, and amphibians on the face of the earth constitute just 3% of the planet's animal biomass.
Human beings and our animals (livestock & pets) constitute 97%.
While estimates vary, there are around 900 million dogs and 600 million cats on earth. This pales in comparison to livestock. We maintain a global herd of about 70

billion (with a "B") livestock animals for food and other products. This translates into 10 livestock animals for each human being on earth.

Plants & Animals, 2

Faced with climate change and other human-caused issues, like loss of habitat, plants and animals have three options, 1) to adapt (evolve), 2) to move (migrate),and 3) to die.

Adapt

For the past 30 million years or so, the earth has been cooling - thanks to all that CO_2 safely sequestered in fossil form underground. During that time life on earth was able to evolve to thrive in the changing, cooler climate.
Given enough time, life can dramatically evolve. In less than one tenth that time, human beings evolved from a small primate the size of a chimpanzee (Australopithecus - Lucy) to us.

Unfortunately, contemporary anthropogenic climate change is happening far too quickly for most species to evolve in response. Leaving them with the next two options:

Migration

Half of life on earth (plants and animals) is now migrating in response to anthropogenic climate change. For the most part, the migration is toward the poles and cooler temperatures.
On land, the average migration rate is 10 miles per year. Ocean life is moving four times faster.

However, life near the North Pole is often moving south as the ice sheet breaks. Polar bears moving down and grizzly bears moving up recently collided and have successfully bred. The first pizzly bear in the wild was discovered in 2006.

As life migrates toward the poles, it can have a range of consequences, some worrisome.
For example, the Zica virus, which was first discovered in Brazil and which is often transmitted by mosquitoes that live in tropical regions, is now in the U.S. There have been over 200 cases believed to be caused by mosquito-borne transmission.

Option #3

If life cannot evolve or migrate, the only option is to die.
For example, coral, which cannot move great distances and cannot evolve fast enough to adapt to rising ocean temperatures and increased ocean acidification (more on this later), are now dying across the globe.

Roughly half of the world's coral reefs have died in the past 3O years. Scientists predict that 90 percent of corals will die by 2050. The film Chasing Coral takes up this issue.

Oceans, Ice, and Land

Over 90% of the heat from climate change has been absorbed by the oceans.
Since the oceans are absorbing CO2, they are also becoming more acidic. Roughly 30 percent of CO2 released by human action has been absorbed by the oceans.

Coral is just one example of sea life impacted by rising ocean temperature and acidity. Other examples include kelp forests and sea turtles.

Warmer air is now melting ice across the planet, such as the massive Antarctic and Greenland ice sheets.
In addition, ice sheets over the ocean, such as the North Pole, are also melting because of warmer waters below. By 2050, ships will likely be able to sail over the North Pole.
Eventually the North Pole will be gone. This will only increase global warming, as the earth's ice sheets reflect heat back into space. In contrast, dark oceans absorb heat.

Thanks to all this melting ice, sea level will certainly rise over the next century.
Conservative estimates are that it will rise by at least one meter (39 inches). Some estimates are for a rise of ten feet, three times that amount.
Since a third of the world's cities are on the coast and over 600 million people live within 40 feet of the ocean, this will have profound impact on human life.
Sea level rise is already impacting a range of places, from Miami, Florida to whole island nations in the Pacific. Before the Flood, the Leonardo Dicaprio film, explores this issue.

Forty percent of land in Bangladesh will likely be lost with just two feet of sea-level rise.
Two feet of sea level rise will flood the entire coast of Florida. Roughly 75% of Florida's population lives in coastal counties.
Miami is already regularly flooding during fair weather due to sea level rise, as the actor Jack Black made clear in the Years of Living Dangerously documentary series:

People, Population, & Justice

Environmental (In)Justice
Poorer people and poorer countries will suffer from climate change more than the wealthy.

The great irony is that wealthier countries and individuals are contributing to climate change far more by emitting far more greenhouse gases.
An average American is responsible for 16.4 metric tons of CO2 or equivalent gases being emitted per year. The average person in Sub-Saharan Africa emits 0.8 tons - less than one twentieth the amount.

While population is certainly an issue with respect to climate change, it can be misleading.
Africa is composed of over 50 countries. Together they have a population that is nearly four times the U.S.
However, since the average African has greenhouse emissions that are 1/20th the average American's, The U.S. is contributing to climate change five times more than Africa. Even if Africa's population doubled, with everything else being equal, the U.S. would still be emitting more than twice as much as the entire continent of Africa.

When Americans suggest that global population is the root problem of climate change and look to places like Africa or India (where per capita CO2 emissions are less 1/10th of the U.S.) as examples, it is not only misguided and simply wrong, it can reveal an underlying racism.
Greenhouse gas emissions should always be thought of as a ratio of emissions to population. If we were to compare Africa to the U.S. using this approach, with lower being better and Africa as the benchmark at 1.0, the U.S. would currently be at around 5.0 even though Africa's population is roughly four times that of the U.S.
In other words, even though Africa's population is around four greater than the U.S., the U.S. is contributing five times more to global climate change than the entire continent of Africa.

We refer to the social inequity of climate change as "environmental justice" or more recently as "climate justice."
"Environmental justice" can refer to any sort of environmental issue, such a point-source pollution. These can be local (such as the water crisis in Flint, Michigan), regional, or global.
"Climate justice" focuses on climate change in particular, which is a global issue.
In both cases, issues of environmental and social justice are often deeply intertwined (which The True Cost documentary makes clear).

Where does wood come from?

In other words, if you plant a tiny acorn and wait a hundred years or so, it will become an oak tree containing thousands of pounds of wood that can be made into things like furniture. Where did most of that mass come from?

Wood chiefly comes from four sources. Interestingly, these correspond to the four classical (Greek) elements: Earth, Water, Air, and Fire.

A) Earth
Without certain elements from the soil, like nitrogen, plants cannot thrive or even survive. This is why farmers add nitrogen to the soil, such as though petrochemical fertilizers or organically through plants that fix nitrogen (like legumes).

B) Water
Without water, plants cannot survive. This is why certain drought-tolerant plants, such as sages, can survive a drought while other plants like turf grass cannot.

C) Air
As with animals, plants cannot survive without air.

D) Fire (energy)
Without solar energy, photosynthesis cannot occur. This is why growers use opaque plastic for weed control.