

**Date:** 10/19/2009

**Team Members:** Claire Jonmaire, Lecie Houston, Michael Pothering

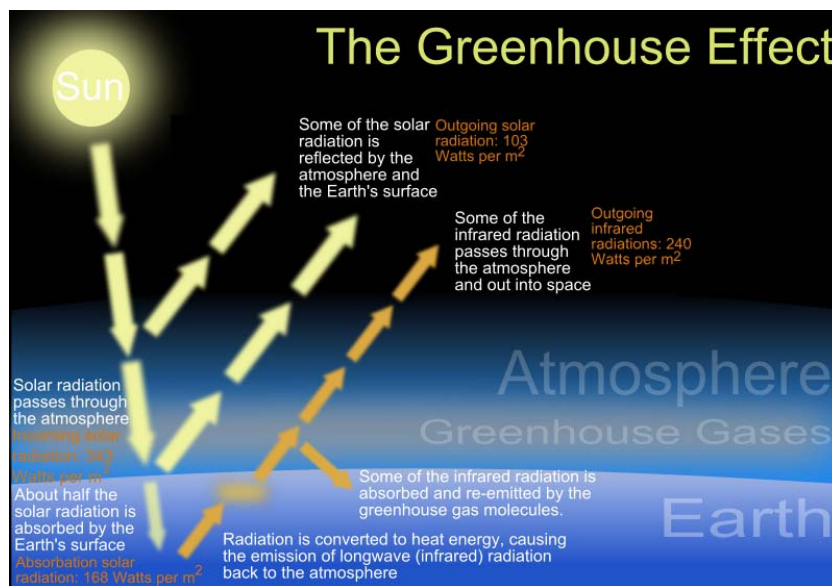
**To:** Dr. Richard Schuman, Ryan Whittington

**Subject:** Judgment Exercise

## Part 1.) Background on climate change

### Mechanics of Climate Change

Climate change is defined by Microsoft Encarta as a “change in global weather patterns: long-term alteration in global weather patterns especially increases in temperature and storm activity, regarded as a potential consequence of the green house effect”. Climate change is proposed to have been caused human-activities and the related carbon emissions often refer to as greenhouse gases<sup>1</sup>.



<http://www.gasdatabases.com/articles/3089/Greenhouse-gases-in-Earth%27s-atmosphere>

The diagram above shows the effect of greenhouse gases (GHG) in the Earth's atmosphere. Solar radiation enters the atmosphere at a rate of 343 Watts/m<sup>2</sup> and about half is absorbed by the Earth's surface at a rate of approximately 168 Watts/m<sup>2</sup>. The radiation is then converted to heat energy, “causing the emission of longwave (infrared) radiation back to the atmosphere”. Because of the presence of greenhouse gases, “some of the infrared radiation is absorbed and re-emitted by the greenhouse gas molecules<sup>2</sup>”.

These Gases Include<sup>2</sup>:

- carbon dioxide
- methane
- nitrous oxide
- halocarbons

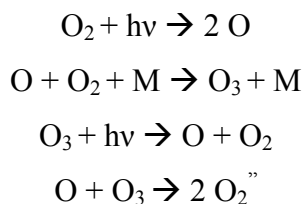
**Figure 1:** A diagram of the effects of greenhouse gases in the atmosphere<sup>2</sup>

### Chemistry of Climate Change

There are a number of different interactions between greenhouse gases and the atmosphere. There are three different reactions that contribute the greatest to ozone depletion including: (1) *Ozone Dissociation (Chapman Mechanism)*, (2) *Carbon Dioxide - Carbonic Acid Equilibrium*, (3) *Oxygen – Nitrous Oxide Equilibrium*, and (4) *Sulfur – Sulfuric Acid Equilibrium*.

#### *(1) Ozone Dissociation (Chapman Mechanism)*<sup>3</sup>

“The original mechanism for atmospheric ozone formation and destruction from oxygen species was suggested by Chapman in 1930. The elementary reactions which constitute the Chapman mechanism are:

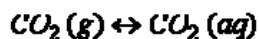


The dissociation of Ozone as outlined in this mechanism contributes to the equilibrium reactions listed below. Depletion of the ozone layer allows a greater level of radiation from the sun to be absorbed by the Earth’s atmosphere<sup>3</sup>.

#### *(1) Carbon Dioxide - Carbonic Acid Equilibrium*<sup>4</sup>

Carbonic acid is formed when atmospheric CO<sub>2</sub> is dissolved in water. The chemical equilibria are listed in the following reaction mechanism.

1) Gas dissolution



2) Carbonic acid formation

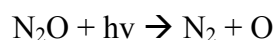


3) Carbonic acid equilibrium

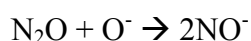
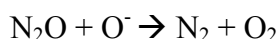


These equilibria exist in nature to control the levels of CO<sub>2</sub> in the environment. The formation of carbonic acid has served to sink carbon within the ocean<sup>4</sup>.

### *(2) Nitrogen Oxides in the Atmosphere*

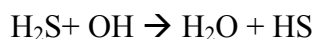
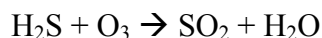


And reaction with singlet atomic oxygen



Nitrous oxides contribute to ozone depletion by absorbing oxygen radicals formed from the Chapman mechanism listed above<sup>5</sup>.

### *(3) Sulfur- Sulfonic Acid Equilibrium*



Sulfuric acid reacts directly with ozone in the atmosphere to degrade the ozone layer. Sulfuric acid also contributes to acid rain, which significantly lowers the pH of many ecosystems rendering life for many plant species impossible<sup>5</sup>.

## **Part 2.) Group position regarding the link between fossil carbon emissions and accumulation of greenhouse gases in the atmosphere and whether human activities are responsible for global warming**

### *Causal Link between Anthropogenic Factors and Climate Change*

After thoroughly providing a peer-reviewed literature search of known databases in the CSA Illumina and Web of Science search engines our group found several forms of evidence for a causal link between anthropogenic activity and climate change. It is noted that, “Atmospheric CO<sub>2</sub> is best reflected by world population... [and a]nthropogenic CO<sub>2</sub> and population have tracked each other extremely well over the past century”<sup>6</sup>. The

growing population underlies the key anthropogenic factors we cited as relevant to climate change: (1) *Fossil Fuel Combustion*, (2) *Land Use Changes* and (3) *GDP Considerations*. Below we have outlined directly quoted evidence from the scientific community supporting this causal relationship.

(1) *Fossil Fuel Combustion* – Fossil fuel combustion is chiefly responsible for production of CO<sub>2</sub> and greenhouse gases (GHGs), “[i]n 1990, the three energy end-use sectors accounting for the largest CO<sub>2</sub> releases from direct fuel use were industry (45% of total CO<sub>2</sub> releases), transportation (21%) and residential/commercial/institutional buildings (29%).”

1. “Fossil fuel combustion is the most important source... there is an unambiguous tracer of the carbon dioxide derived from fossil fuel...it is possible to calculate directly that most of the increases in CO<sub>2</sub> in the past several decades is due to fossil fuel combustion and not deforestation”<sup>7</sup>
2. “CO<sub>2</sub> will be responsible for more than half of the anticipated global warming over the next century... The modern increase is superimposed on this natural variation; it begins with carbon dioxide concentrations at their high interglacial level and goes up from there, outside the range of the past”<sup>7</sup>.
3. “It is very unlikely that atmospheric levels of CO<sub>2</sub> equivalent can be stabilized much below 450 ppm during this century. This virtually guarantees significant additional warming and associated to some people and places around the world”<sup>8</sup>.
4. Human activities have increased greenhouse gas concentrations to levels much higher than those found before the Industrial Revolution. These activities have caused the global average temperature to increase by 1°C although parts of the world have experienced changes in temperatures much greater than the global average. The increase in temperature is directly proportional to the increase in greenhouse gases caused by greenhouse gas emitters and changes to local ecosystems that have an effect on carbon storage<sup>8</sup>.

5. “Global green house gas emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004”<sup>9</sup> from (IPCC, 2007: Summary for Policymakers).
6. “If the concentration of certain trace gases (carbon dioxide (CO<sub>2</sub>), water vapor (H<sub>2</sub>O), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), tropospheric ozone (O<sub>3</sub>), and chlorofluorocarbons (CFCs)) increases, the atmosphere's absorption of long wave radiation (thermal radiation from the Earth's surface) will increase. Some of this energy will be radiated downward, heating the surface and increasing the surface temperature.”<sup>10</sup> From (EPA, The Potential Effects Of Global Climate change On The United States).

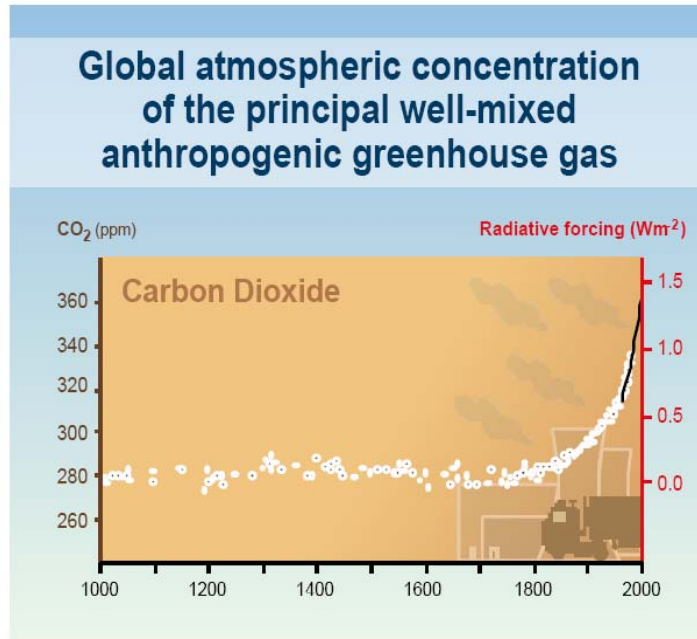
(2) *Land Use Changes* – It is currently estimated that, “[o]ne third to one half of the terrestrial surface, including some of the best land in terms of water supply and soil fertility, has been altered directly and substantially by human activity”<sup>6</sup>.

1. “Land use change made the dominant contribution to increasing concentrations of carbon dioxide in the atmosphere in the 19<sup>th</sup> century... [it] is the most important cause of increases in atmospheric concentrations of the greenhouse gases methane and nitrous oxides”<sup>7</sup>.
2. “Conversion of forest to pasture increases albedo and decreases canopy roughness... the net effect is an increase in local temperature and a decrease in humidity; these in turn can affect the potential for forest regeneration”<sup>7</sup>.

(3) *GDP Considerations*

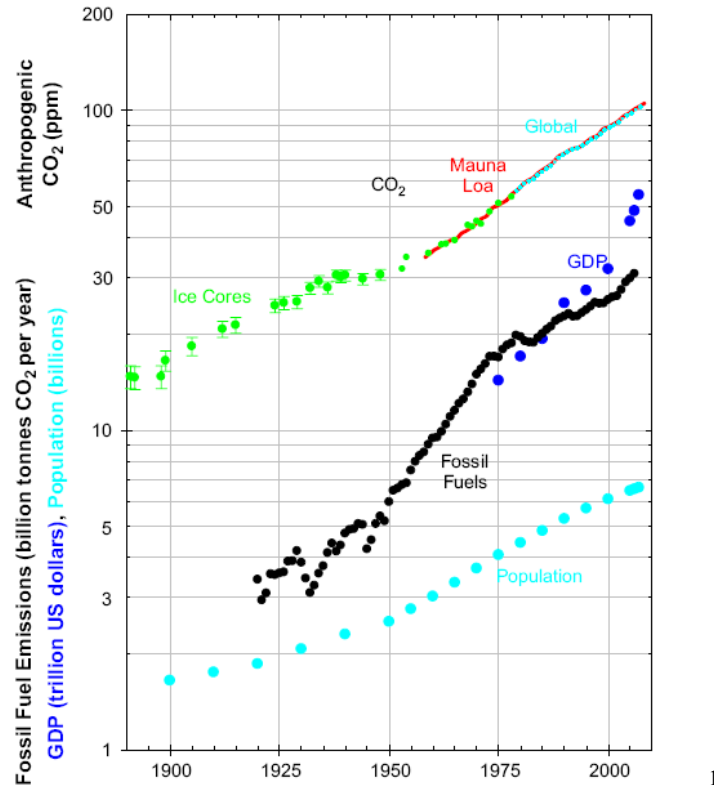
1. “In the absence of funding new technologies, many poorer nations will need to emit more greenhouse gases than their current level in order to meet basic human needs for food, shelter and security. Other nations’ current level of emissions far exceeds those needed to meet basic human needs”<sup>8</sup>.
2. “[T]he denial of global warming is an instance of the tragedy of the commons. Nobody profits directly from bearing the costs of climate policies, while all benefit if others bear these costs. The higher the costs an individual has to bear (relative to all others), the lower is his or her motivation”<sup>11</sup>.

The following figures below display the causal relationship between the main anthropogenic factors and climate change.



11

**Figure 1:** Chart showing the rise in CO<sub>2</sub> concentration over the last millennium<sup>12</sup>.



**Figure 2:** A graph of “anthropogenic carbon dioxide, fossil fuel emissions, GDP, and world population versus time information sources: United Nations, World Bank, Energy Information Administration, and Carbon Dioxide Information Analysis Center”<sup>7</sup>.

Figure 1 represents the cyclic seasonal variations of atmospheric carbon dioxide in the atmosphere. From approximately 1950, it is clear seasonal averages have increased greatly with the concentration of CO<sub>2</sub> produced from human activity. The radiative forcing indicates the relative level of surface irradiation from the sun. From figure 2, it is also clear that anthropogenic activities such as population growth, fossil fuel combustion, and gross domestic product all follow nearly the same growth rate as carbon dioxide found in the atmosphere and ice cores.

We used strictly peer-reviewed and governmental documentation in order to base our claim. We feel this search has ultimately proven the causal relationship between population growth, fossil fuel consumption, GDP, and land use changes with changing

the global climate. We did not find convincing evidence from any reputable source suggesting anything to the contrary.

**Part 3.) Group position regarding whether it has been determined beyond a reasonable doubt that the earth is warming because of man-made problems**

According to statements made by Senator Inhofe, the concept of global climate change resulting from human-activities has not been proven beyond a reasonable doubt. Inhofe insists there is no direct correlation between carbon emissions and global warming and that there is proof to back up those claims. However, scientific research time and time again has demonstrated a link between carbon emission and climate change.

The Senators statement that the phenomenon of climate change has been “vigorously disputed in the scientific community” is a stretch. There is some resistance to the phenomenon, mostly coming from governmental or corporate agencies that might have economic interest in the issue. After researching the topic using Web of Science search engine, which searches peer reviewed scientific journals, proved beyond a reasonable doubt that there is a definite link between green house gasses (GHG) and climate change. Scientists published an article NATO Science Series IV Earth and Environmental Sciences titled “Influences of the anthropogenic emissions and atmospheric chemical processes on climate in the XXI century”, which examined four scenarios of GHG emissions as well as additional anthropogenic gases. Specific to each scenario, scientists calculated the troposphere content of GHGs and projected those numbers until 2010. It has been measured that the average ground temperature of the earth has increased at an alarming rate since the turn of the 20<sup>th</sup> century.

By claiming a “significant dispute” to global warming, one must provide well researched documentation that backs up the statement. However, well researched, peer reviewed documentation that refutes the claim is difficult to find. The Web of Science search engine did not have any articles that explicitly challenged the global warming phenomenon. Turning to broader search engines, more information was available. One



book in particular titled “Meltdown: The Predictable Distortion of Global Warming by Scientists, Politicians, and the Media”, written by Patrick J Michaels, a Professor of Environmental Sciences at University of Virginia and also reviewed by Sallie Baliunas of Harvard University, explored the exaggerations and misstatements of global warming, something he calls “predictable distortions”.

Michael’s theory suggests that any type of change in the environment has its positive and negative effect and maybe the earth is not doomed by the presence of global warming. Using the example of hurricane research to strengthen his argument, he stated “only 10 percent of the behavior of hurricanes in the Atlantic Ocean (where there are the best long term records) is related to sea surface temperatures. When that is factored in, any changes in hurricanes related to global-warming become undetectable over the next century.” Another example he cited is the correlation of warming to the size of Mount Kilimanjaro’s ice cap. “In the first warming, 45 percent of Kilimanjaro's ice cap disappeared. When the planet subsequently cooled, it lost another 21 percent. In the recent warming, another 12 percent has gone the slowest rate of loss in the last 100 years. Some 4,000 to 7,000 years ago, the earth was a degree or two warmer than it is today, and yet Kilimanjaro's glaciers were greatly expanded compared to the current era.”

Patrick Michaels is not saying that the earth is not warming because there is documented research that shows the average temperature of the earth has increased, but he is suggesting the extent and severity of climate change isn’t as bad as many scientists and news outlets lead people to believe.

There is also further evidence in a peer-reviewed article by Hofmann, Butler et al. in 2009 suggesting that, “the CO<sub>2</sub> increase does not reflect fossil fuel changes very well, in particular the oil crises inflections”<sup>5</sup>. However, the authors do not refute the premise that global warming is occurring. They argue instead that the chief concern regarding global warming is world population more so than fossil fuel consumption<sup>5</sup>.

Even with the listed moderate arguments against the global warming debate, the lack of evidence refuting the process indicates that global warming is a very real concern to the general public. Overall, it is generally agreed across the scientific community that the climate is changing and human-activities are a key contribution. It is clear that the extent and long term projection of the effects of global climate change is the question. Senator Inhofe was correct when saying that there is opposition to climate change but not to the extent at which he stated. You cannot refute facts but one must be aware of the fact that the conclusions drawn from the facts are for the most predictions and only time will tell what will happen due to climate change.

#### **Part 4.) Group conclusion regarding judgment**

The global warming debate is a classic example of flaws in judgment concerning expert opinion. High profile individuals who claim to be experts in their field often make statements without backing them up. These statements can quickly become faulty common knowledge. For example, in the excerpt from the piece of literature, *From Chicken Little to Dr. Pangloss* by Oreskes, Dr. Nierenberg's influence and reputation as an expert quickly gave him power to sway the scientific and political communities' opinions on climate change.

“In September 1942 he entered Columbia University for his PhD and soon found himself working on isotope separation in the Manhattan Project. After graduating, he taught nuclear physics at the University of California, Berkeley, and in 1953 became director of Columbia University's Hudson Laboratory, created to continue scientific projects begun on behalf of the U.S. Navy during World War II. He subsequently held a series of positions at the interface between science and politics, including NATO's assistant secretary general for scientific affairs. In 1965 he became Director of the Scripps Institution of Oceanography, reinforcing its commitment to applying scientific knowledge to national security problems. Nierenberg's appointment at Scripps was broadly supported in the weapons community... Climate scientists had been suggesting that the government had to *do* something about greenhouse gases, but Nierenberg concluded that was not so, primarily because humans were capable of adapting to whatever changes ensued”(From *Chicken Little to Dr. Pangloss*)<sup>15</sup>.

Examples of expert opinion gone wrong are also seen in the Journal of American Physicians and Surgeons paper *Environmental Effects of Increased Atmospheric Carbon Dioxide*<sup>16</sup> and subsequent online protest. Individuals uneducated in the principles of global warming were clearly swayed in what they viewed to be “expert opinion”.

Some forms of misjudgment also come from concerns about economy. In a Rock Ethics Publication they state that overall, “the developed countries are most responsible for temperature increases that the Earth has experienced recently, having contributed the greatest percentage to historical increases in GHG emissions”<sup>8</sup>. Despite the uncertainty of economic effects from limiting the anthropogenic factors that lead to global warming, many countries are unwilling to change for fear of hindering economic growth. The Rock Institute makes a great claim that any act that may prevent basic human rights is unethical and that fear of economic decline is no excuse for limiting human life<sup>8</sup>.

Ultimately, we all agree on the fact that global warming is a present threat to the global community. We are more aware of the fact that false information can be presented to us as fact when in actuality there are many falsehoods. To the politicians and scientists that may have been swayed from Nierenberg, and others, they clearly were misinformed in their judgment process. From this activity it has become clear that scientists and politicians seen in the media may have ulterior motives, whether it by funding, career advancement, economic incentives, or power. These factors cloud judgment, impair the ability to interpret factual information ethically, and ultimately mislead the public.

## References

<sup>1</sup>Encarta. "Climate Change." *MSN Encarta*. Microsoft, n.d. Web. 18 Oct. 2009.

<[http://encarta.msn.com/dictionary\\_701705058/climate\\_change.html](http://encarta.msn.com/dictionary_701705058/climate_change.html)>.

<sup>2</sup>Gas Databases. "Greenhouse gases in Earth's atmosphere." *Gas Databases*. N.p.,

n.d. Web. 19 Oct. 2009. <<http://www.gasdatabases.com/articles/3089/>

Greenhouse-gases-in-Earth%27s-atmosphere>.

<sup>3</sup>Flynn, PhD, George. "The Kinetics of Atmospheric Ozone." *Intensive General Chemistry*. 2009. PDF file.

<sup>4</sup>*Carbon Dioxide - Carbonic Acid Equilibrium*. (2004, August 03). Retrieved October 2009, from Utha State University Website:

<http://www.chem.usu.edu/~sbialkow/Classes/3600/Overheads/Carbonate/CO2.html>

<sup>5</sup>Manahan, S. E. (2005). *Environmental Chemistry 8th Edition*. Retrieved October 2009, from Google Books:

[http://books.google.com/books?id=k01YDY2vQwoC&pg=PA310&lpg=PA310&dq=nitrous+oxide+atmosphere+equilibrium+chemistry&source=bl&ots=IzhkXGGWzS&sig=f2R1OKWxqViropifTkQrz7-0zP0&hl=en&ei=wM7bSsCrM4ae8AaEls23BQ&sa=X&oi=book\\_result&ct=result&resnum=8&ved=0CDEQ6A](http://books.google.com/books?id=k01YDY2vQwoC&pg=PA310&lpg=PA310&dq=nitrous+oxide+atmosphere+equilibrium+chemistry&source=bl&ots=IzhkXGGWzS&sig=f2R1OKWxqViropifTkQrz7-0zP0&hl=en&ei=wM7bSsCrM4ae8AaEls23BQ&sa=X&oi=book_result&ct=result&resnum=8&ved=0CDEQ6A)

<sup>6</sup>Hofmann, David J, James H. Butler, and Pieter P. Tans. "A new look at atmospheric carbon dioxide." *Atmospheric Environment* 43 (Oct. 2008): 2084-2086. *ScienceDirect*. Web. 17 Oct. 2009.

<sup>7</sup>Vitousek, Peter M. "Beyond Global Warming: Ecology and Global Change." *Ecology* 75.7 (1994): 1862-1876. *JSTOR*. Web. 19 Oct. 2009.

<sup>8</sup>Brown, Donald, and Nancy Tuana et al. "White Paper on the Ethical Dimensions of Climate Change." 2-38. Print.

<sup>9</sup>Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K., et al. (2007). *Climate Change 2007: The Physical Science Basis*. Cambridge University Press.

<sup>10</sup>Bufalini, J., Burke, L., & et al. (1989). *The Potential Effects of Global Climate Change on the United States*. U.S. EPA Office of Policy, Planning, and Evaluation. <sup>11</sup>Sandvik, Hanno. Public concern over global warming correlates negatively with national wealth. *Climate Change* 90: 333-341. *SpringerLink*. Web. 6 Mar. 2007.

<sup>12</sup>Gitay, H., Suárez, A., Watson, R., & Dokken, D. (2002). *IPCC Technical Paper V: Climate Change and Biodiversity*.

<sup>13</sup>Larin NK, Ugarov AA Barnes I Source: GLOBAL ATMOSPHERIC CHANGE AND ITS IMPACT ON REGIONAL AIR QUALITY, *NATO Science Series IV Earth and Environmental Sciences*, **2002**, 16, 287-293.

<sup>14</sup>Michaels, Patrick J. "Meltdown: The Predictable Distortion of Global Warming by Scientists, Politicians, and the Media." CATO Institute. The Cato Institute 1000 Massachusetts Avenue, NW Washington, DC 20001. 18 Nov. 2004. *CATO Institute*. Web. 19 Oct. 2009. <<http://www.cato.org/event.php?eventid=1676>>.

<sup>15</sup>Orkeskes, Naomi, Erik M. Conway, and Matthew Shindell. *From Chicken little to Dr. Pangloss: William Nierenber, Global Warming, and the Social Deconstruction of Scientiric Knowledge*. Print.

<sup>16</sup>Robinson, Arthur B., Noah E. Robinson, and Willie Soon. "Environmental Effects of Increased Atmospheric Carbon Dioxide." *Journal of American Physicians and Surgeons* 12.3 (2007): 79-90. Print.