The matter is urgent. The health of the world’s population is at risk. The time for action is now.

References available at www.cmej.org.za

The carbon cycle
Louis Reynolds, MB ChB, FCP (Paed)
Associate Professor, Education Development Unit, Faculty of Health Sciences, University of Cape Town

Correspondence to: L Reynolds (l.reynolds@uct.ac.za)

Understanding the global carbon cycle is the key to understanding climate change. The carbon cycle makes it clear that, if we want our grandchildren and their children to live decent lives, we have to achieve a world free of fossil fuels – a post-carbon civilisation – within a few years.

Carbon is essential to life. All living organisms are constructed out of carbon-containing organic molecules. These are made possible by the carbon cycle: the exchange of carbon between the earth’s carbon reservoirs, as shown in Fig. 1.

The diagram shows how an enormous carbon cycle moves carbon between these reservoirs in a number of sub-cycles. It shows carbon reservoirs (in gigatons), and the flux between them (in gigatons per year).

The sub-cycles can be grouped into biological cycles (i.e. between the atmosphere and the land, ocean surface and vegetation) and geological cycles (exchanges with the deep ocean, sediments and rocks, including the formation – but not the combustion – of ‘fossil fuels’).

Panel 1. Durban Declaration from the Global Climate and Health Summit

Having gathered at the first Global Climate and Health Summit in Durban on 4 December 2011, we – as health professionals, public health advocates, and healthcare policy makers from more than 30 countries – hereby call on national delegations to the UNFCCC’s 17th Conference of the Parties to:

- Recognise the health benefits of climate mitigation and take bold and substantive action to reduce global greenhouse gas emissions in order to protect and promote public health.
- Ensure greater health sector representation on national delegations as well as within key mechanisms of the UNFCCC, recognising the role of the World Health Organization as the voice for public health within the UN system.
- Actively include the participation and empowerment of youth, women and indigenous peoples in the climate change processes.
- Adopt a strong second commitment period of the Kyoto Protocol which currently includes emission reduction targets for the time until 2012, to protect and continue the only binding climate law the world has.
- By 2015, negotiate a fair, ambitious and binding agreement that, consistent with the Prescription for a Healthy Planet, endorsed by more than 130 health organisations in Copenhagen in 2009:
  - Places the protection of human health as a primary objective of any agreement.
  - Establishes an ambitious fair shares framework to reduce global emissions (based on the principles of equity and common but differentiated responsibilities and respective capabilities) in order to avoid a global public health disaster.
  - Fosters both energy efficiency and clean, renewable energy that protects public health by reducing both local and global pollution.
- Provides the immediate necessary resources to operationalise the Green Fund, and in the longer term, appropriate mitigation and adaptation funding required to address the health impacts of climate change, assuring all countries’ rights to sustainable development and their ability to pursue a low carbon development pathway.

The diagram shows how an enormous carbon cycle moves carbon between these reservoirs in a number of sub-cycles. It shows carbon reservoirs (in gigatons), and the flux between them (in gigatons per year).

The sub-cycles can be grouped into biological cycles (i.e. between the atmosphere and the land, ocean surface and vegetation) and geological cycles (exchanges with the deep ocean, sediments and rocks, including the formation – but not the combustion – of ‘fossil fuels’).

Fig. 1. The carbon cycle. (The diagram is a file from the Wikimedia Commons. Commons is a freely licensed media file repository. The copyright owner has given permission for it to be used freely for any purpose and without any conditions. See: http://en.wikipedia.org/wiki/Carbon_cycle.)
Geological cycles run at geological time-scales of millions of years. This means that for practical purposes, no new fossil fuels are being produced. Fossil fuel burning is not a feature of the natural biological cycle. The geological cycle has no meaningful relationship with climate change.

Natural biological carbon cycles, on the other hand, run at seasonal or annual time scales – we can see them happening in our daily lives: photosynthesis in green leaves, respiration, veldfires and combustion of wood, rotting plants, and so on.

Using the fluxes in the diagram, we can construct a natural carbon balance where positive and negative contributions refer respectively to removing carbon from, or releasing it into, the atmosphere. Table 1 demonstrates this in gigatons of carbon per year.

This means that the planet, in its natural, pre-industrial state, is a carbon sink, capable of removing 2.2 gigatons of carbon from the atmosphere each year, mainly through photosynthesis. It is this natural solar-powered ability to sequester carbon that made life on earth what it is today by reducing the atmospheric CO₂ concentration down to 0.04%, and safely storing the sequestered carbon, with all the solar energy that went into its photosynthesis, as what we now call fossil fuels.

The industrial revolution brought an end to this. Ever since we discovered that there are enormous amounts of stored fossil fuel energy, we have been doing our best to reverse the process. To the negative side of our carbon balance we now have to add 5.5 gigatons of carbon from fossil fuel burning per year. This brings the overall balance to minus 3.3 gigatons of carbon, accumulating in the atmosphere as CO₂, and leading to climate change and global warming through its greenhouse effect.

Fig. 2 shows the current carbon reservoirs that are part of this rapid carbon cycle. Fossil fuels are included because, since the industrial revolution, they have become part of the rapid biological cycle. However, unlike the exchange of carbon among the other reservoirs, fossil fuel combustion is a one-way process. It is not a true cycle. Effectively, it means moving carbon from the tall black fossil fuel bar on the chart and piling it onto the shorter blue atmosphere.

### Table 1. Positive and negative contributions to the biological carbon sub-cycle

<table>
<thead>
<tr>
<th>Sub-cycle</th>
<th>Positive</th>
<th>Gt C</th>
<th>Negative</th>
<th>Gt C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land and vegetation</td>
<td>Mainly photosynthesis</td>
<td>121.8</td>
<td>Respiration</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Decay</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Burning biomass</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Respiration, decay</td>
<td>90</td>
</tr>
<tr>
<td>Surface ocean</td>
<td>Mainly photosynthesis</td>
<td>92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>213.8</td>
<td></td>
<td>211.6</td>
</tr>
</tbody>
</table>
bar – the greenhouse gas-containing bar, responsible for climate change.

The result is, effectively, reversal of the process that supports life as we know it – planetary suicide. The planet cannot recycle all that carbon, and if we don’t reverse it, will become uninhabitable by humans.

The only lasting solution: Keep fossil fuels in the earth, where nature has put them

Ecuador has large oil reserves in one of the most biodiverse regions of the world. Some years ago social movements and civil society organisations who wanted to protect the biodiversity and indigenous lifestyles began a campaign for a world emancipated from the need to burn fossil fuels – a post-oil civilisation. The campaign is supported by the Ecuadorian government, and by campaigning groups in a growing number of countries. Germany has pledged financial support. The campaign slogan is: *Keep the oil in the soil, keep the coal in the hole, and keep tar sand in the land.*

Although it originated in Ecuador around local issues, the campaign has worldwide implications. If we look at the carbon cycle and its implications, it is clear that its simple, yet radical, slogan points to the only effective and lasting way to combat global climate change.

**How well are we teaching health science students about climate change and health?**

Bob Mash, MB ChB, DRCOG, DCH, MRCGP, FCFP, PhD

Head, Family Medicine and Primary Care, Stellenbosch University

Correspondence to: Bob Mash (rm@sun.ac.za)

Climate change and the issues of sustainable development are a new component of the health sciences curriculum. While the topic is now included in basic education the relevance to healthcare providers, health systems and the healthcare industry needs to be incorporated within higher education institutions.

Health sciences faculties are themselves part of the problem. For example, the Faculty of Health Sciences at Stellenbosch University used 16.4 million kWh in 2010, making it a

**Table 1. Consensus on the medical school curriculum for climate change**

**Learning objectives**

We propose nine learning objectives, of which four are core objectives to be used by all educators, regardless of the teaching format. Learning objectives are based on the WHO Health and Climate Change module.

**Core objectives (with optional sub-topics)**

1. Climate change as an environmental hazard: explain how climate change impacts on health inequalities and the wider determinants of health
   a) Outline the effects of climate change on health:
      • Mechanisms by which climate change affects the wider determinants of health
      • Disease processes affected by climate change
      • Examples of health effects that have already been observed
      • Examples of projected health effects
   b) Describe the impact of climate change on health inequalities:
      • The exacerbation of inequalities through the impact of climate change
      • The role of inequalities in causing climate change
      • The theory of contraction and convergence
   c) Discuss ethical issues over distributive justice in carbon reduction

2. Define the relationship between adaptation and mitigation and the health co-benefits of each
   a) Define mitigation and adaptation
   b) Give an example of an adaptation measure which runs counter to mitigation strategies
   c) Give an example where adaptation and mitigation strategies are synergistic
   d) Health co-benefits relating to policies on:
      • Redistribution of resources (e.g. carbon allowances)
      • Transport, food production, energy generation, home energy efficiency
      • Population control