

The Science of Chemical Safety
Essential Toxicology - 3

Environmental Toxicology

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Environmental Toxicology

- Large exposures to chemicals can affect human health directly or indirectly by disrupting ecological systems that exist in rivers, lakes, oceans, streams, wetlands, forests and fields.
- The release of chemicals into the environment can have global impacts

Global Impacts - 1

- Chemicals can be transported throughout the atmosphere and are not bound by political borders
- DDT and its derivatives are found in the Arctic and Antarctic.
 - They have never been used there

Global Impacts - 2

- Radionuclides from the Chernobyl nuclear power station explosion in the Ukraine in 1986 still contaminate farms in Britain in 2000 and their lambs cannot be sold for human consumption

Air Pollution - 1

- Acid precipitation (acidic rain, snow, particulates etc) is a result of air pollution caused by burning fossil fuels such as coal and oil and other compounds containing nitrogen and sulfur
- Acid precipitation results from the solution of nitrogen and sulfur oxides to give a mixture of nitrous, nitric, sulfurous and sulfuric acids

Air Pollution - 2

- Acid precipitation may reduce the pH of lakes below 6, releasing aluminium ions which kill the fish
 - Note - above pH 6, aluminium in water is increasingly in the form of hydroxides which are not bio-available

Air Pollution - 3

- The products of burning fossil fuels are nitrogen oxides (NO_x), sulfur oxides (SO_x), volatile organic compounds (VOC), carbon oxides (carbon monoxide and carbon dioxide), and particulates
 - Environmental damage may result from carbon monoxide (CO) and carbon dioxide (CO_2) contributing to the “greenhouse effect”

Air Pollution - 4

- The “greenhouse effect” is heating of the environment because heat loss from the surface of the earth through the atmosphere is reduced by reflection of infrared radiation from gases and vapours such as CO₂ and water vapour
 - See slide 17 on global warming

Air Pollution - 5

- Air pollution affects human health directly as a result of lung damage and indirectly through damage to crops, buildings, and acidification of natural waters
 - Sulfur and nitrogen oxides aggravate bronchitis and asthma, putting stress on the heart: they killed more than 4,000 people, mostly elderly, in London in 1952 as a direct result of these harmful health effects

Air Pollution - 6

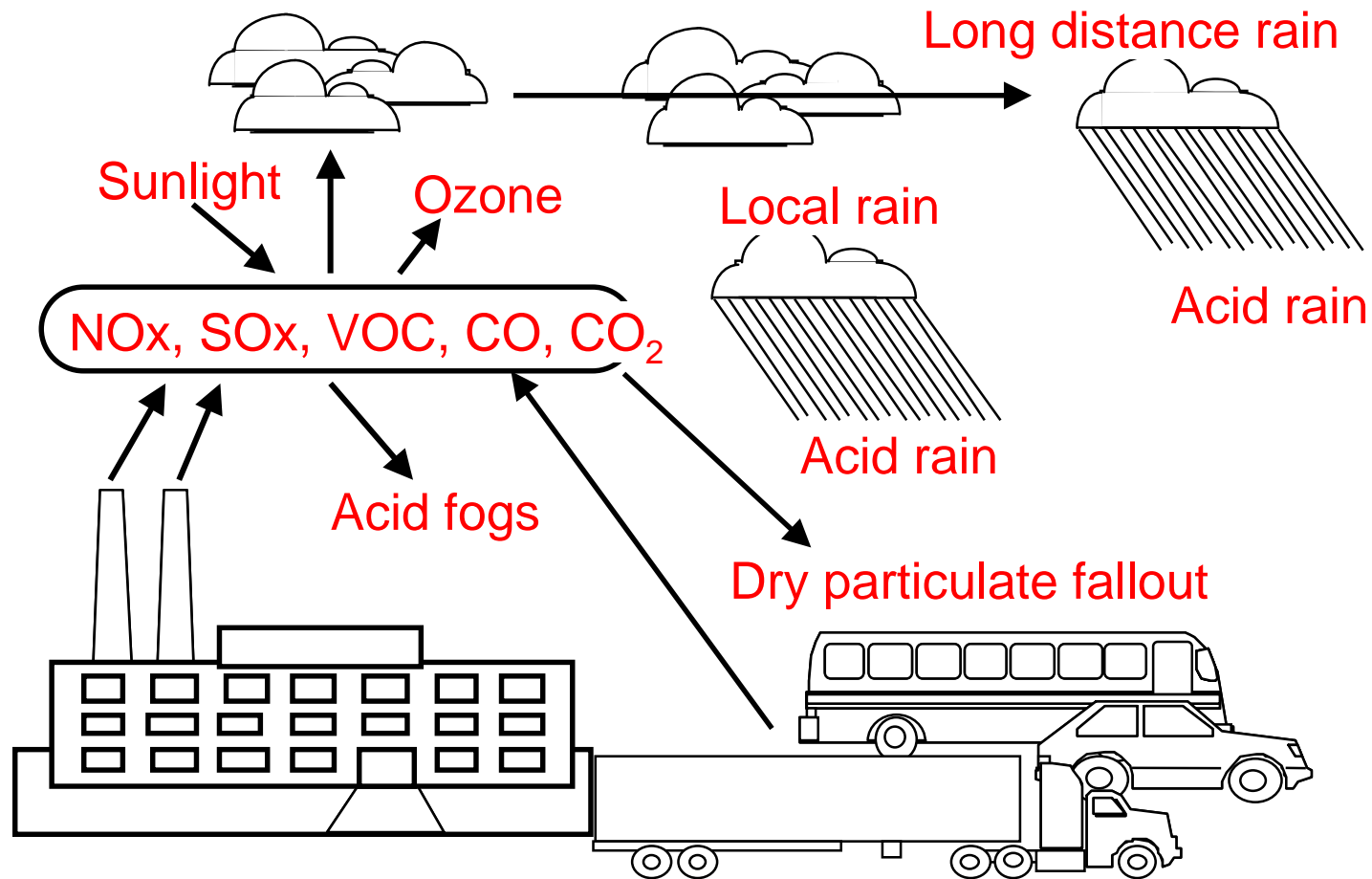
- Volatile organic compounds (VOCs), in sunlight, react with ozone to produce highly reactive compounds which attack lung tissue
- Carbon monoxide reduces oxygen uptake by binding to haemoglobin
- Inhaled particulates reduce lung function

Preventing Air Pollution

- Methods available for reducing emissions of acid rain include burning low sulfur fossil fuels, trapping pollutants in emitting stacks (for example - trapping the sulfur oxides with lime, CaO , to make gypsum, CaSO_4), and removing sulfur from coal and other fuels
 - Note - trapping pollutants may still leave a problem of waste disposal although, in the example given, gypsum can be used to make cement

Preventing Air Pollution - 2

- Each preventive method has its benefits, and all have their associated costs
 - Trapping the sulfur oxides has been favoured in some countries but it poses the problem of what to do with excess gypsum if there is already enough to meet demand for cement



The formation and distribution of acid precipitation
 - acid rain, acid fog and acid particulates

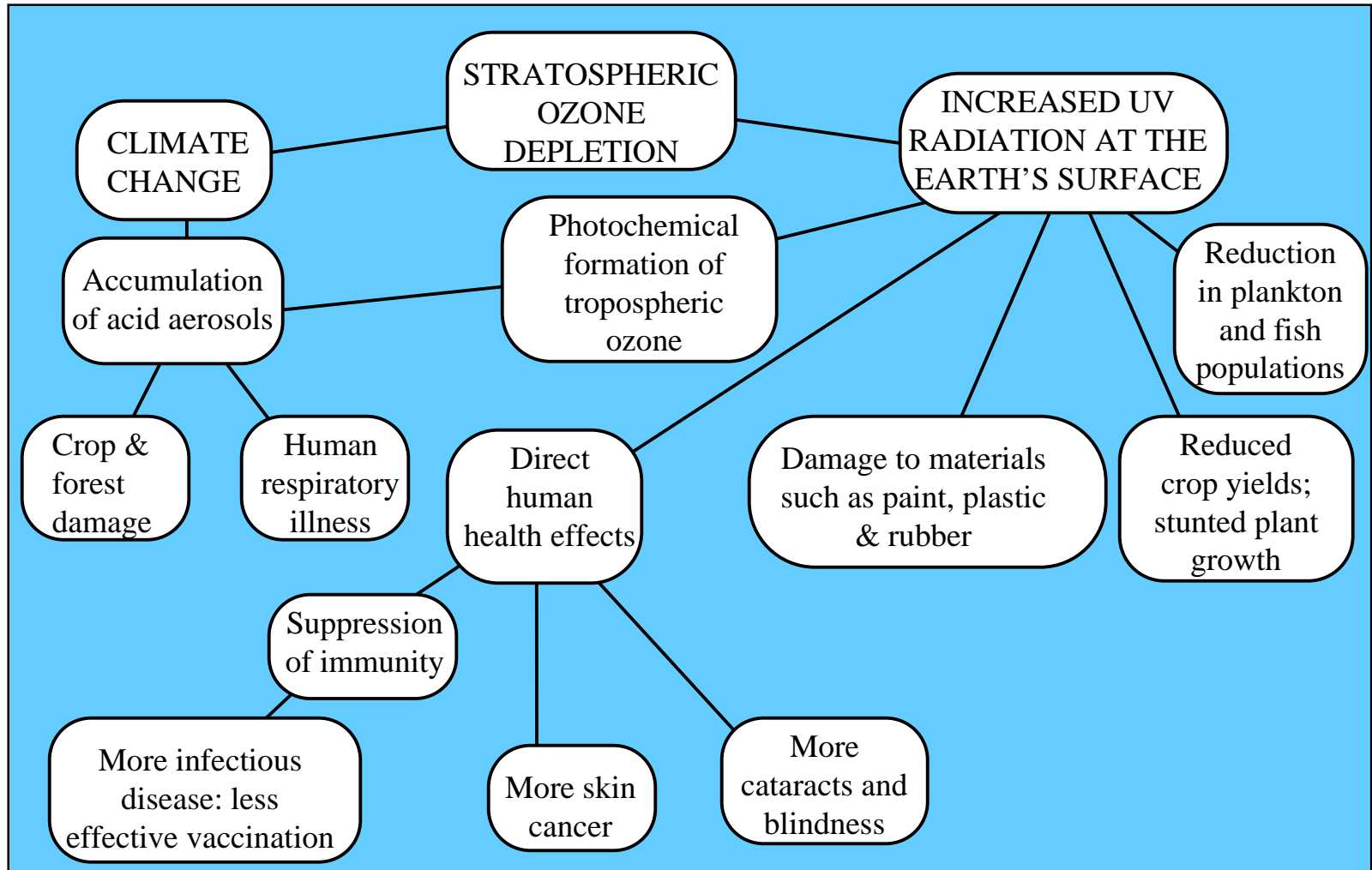
Stratosphere Ozone Depletion

- Ozone depletion in the upper stratosphere is a worldwide problem that has required co-operation by world leaders
- Ozone in the stratosphere protects us from the harmful effects of excess ultraviolet radiation from the sun which, among other things (see below), causes skin cancer

The Montreal Protocol

- CFCs - chlorofluorocarbons (formerly used extensively as refrigerants and solvents) have entered the stratosphere and catalytically reacted with the ozone there, reducing the amount so much that holes have appeared in the ozone layer
- The Montreal Protocol of 1987 is an international treaty signed by many countries agreeing to reduce the release of CFCs

Effects of Ozone Depletion



Global Warming - 1

- It appears that the earth is slowly rising in temperature (global warming)
 - Global warming is thought to be due to increasing levels of carbon dioxide and water vapour in the atmosphere caused by large scale burning of fossil fuels
 - The carbon dioxide and water vapour permit radiation from the sun to heat the earth but prevent loss of heat, in the form of infrared radiation (the greenhouse effect)

Global Warming - 2

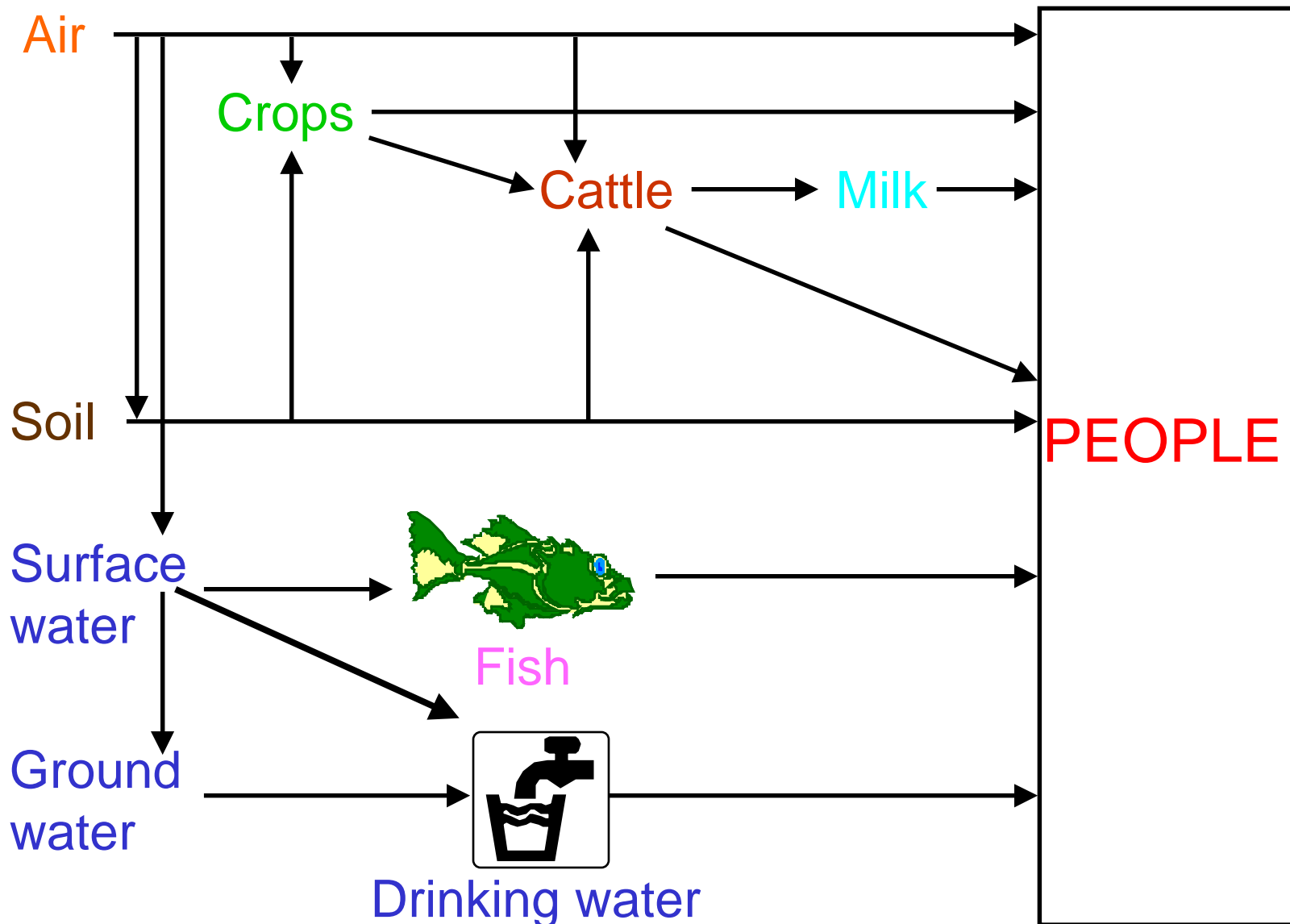
- Increased earth temperature is changing the climate and thus the ecology all round the world
 - Increased temperature increases the rate of transformation of chemicals by micro-organisms and facilitates transfer of volatile substances through the air

Environmental Exposure Routes

- All the changes that occur in the environment affect people
- Ultimately people can be exposed to any substance that enters the environment
- Some of the more obvious routes of exposure of people are shown in slide 21

Risk Assessment for Environmental Exposure

- Risk assessment for the possible effects of any substance entering the environment which may harm people must sum up the exposures through all routes in order to determine the total exposure and then the possible effect



Potential exposure routes in assessing exposure to the general public

Self Assessment - 3.1

True or False?

- Some chemicals can spread throughout the world from their point of release - see slide 3
- Acid rain contains nitric and sulfuric acids - see slide 5
- Acidification of natural waters to pH 6.5 is enough to poison fish - see slide 6
- Air pollution affects only human beings - see slides 6 & 18

Self Assessment - 3.2

True or False

- Trapping sulfur oxides as gypsum is the solution to the problem of air pollution - see slide 11
- Environmental effects of chemicals may cause harm indirectly by increasing exposure to natural components of the environment - see slides 14 to 18
- The same chemical can reach humans by different routes; the total exposure by all routes determines the harm caused - see slides 20 and 21

Self Assessment - 3.1

Checklist

- Some chemicals spread throughout the whole world from their point of release - **True**
- Acid rain contains nitric and sulfuric acids - **True**
- Acidification of natural waters to pH 6.5 is enough to poison fish - **False**
- Air pollution affects only people - **False**

Self Assessment - 3.2

Checklist

- Trapping sulfur oxides as gypsum will solve the problem of air pollution - **False**
- Environmental effects of chemicals may cause harm indirectly by increasing exposure to natural components of the environment - **True**
- The same chemical can reach humans by different routes; the total exposure by all routes determines the harm caused - **True**