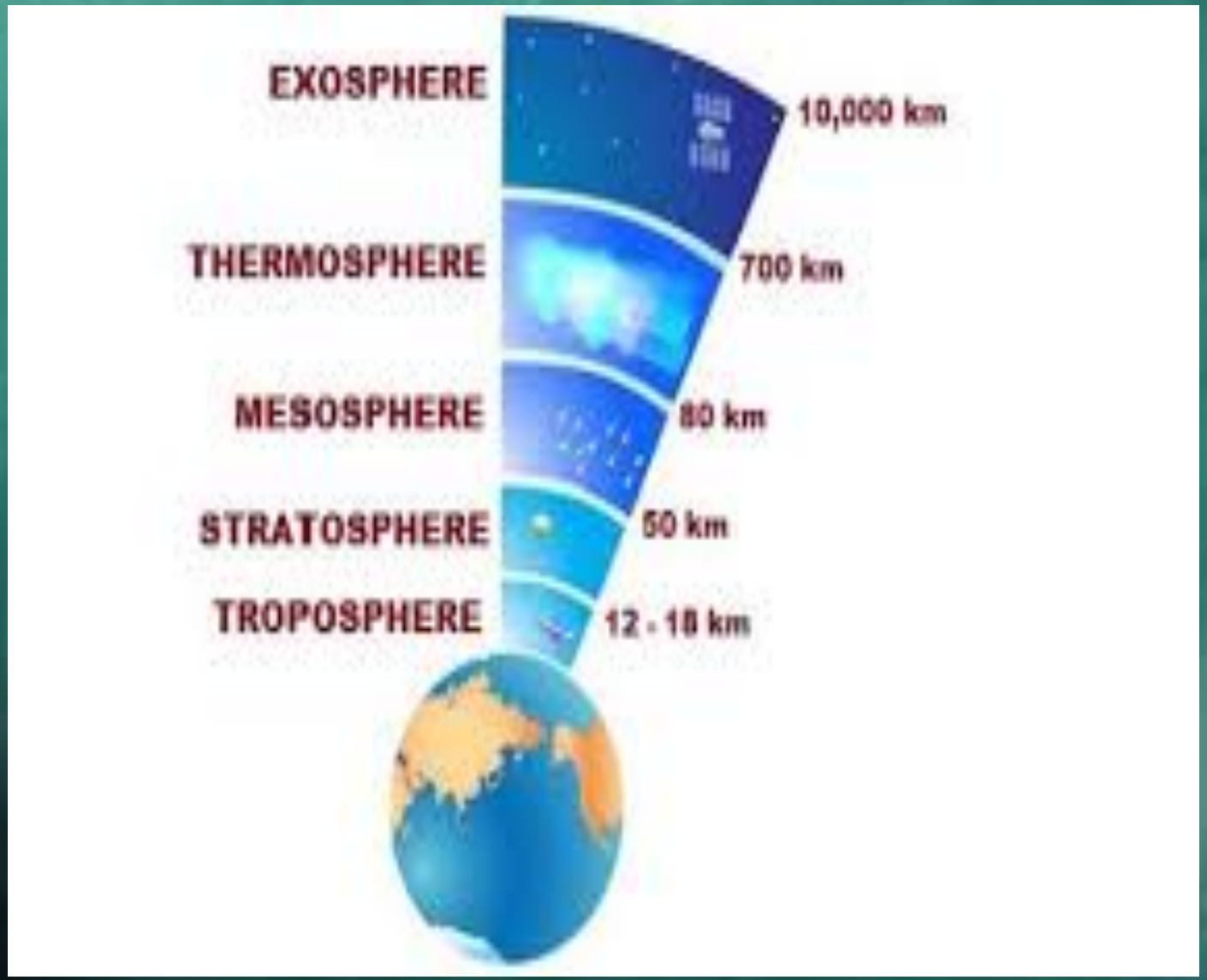
OZONE LAYER DEPLETION

Dr Indranil Ghosh

Associate Professor

Definition of Ozonosphere

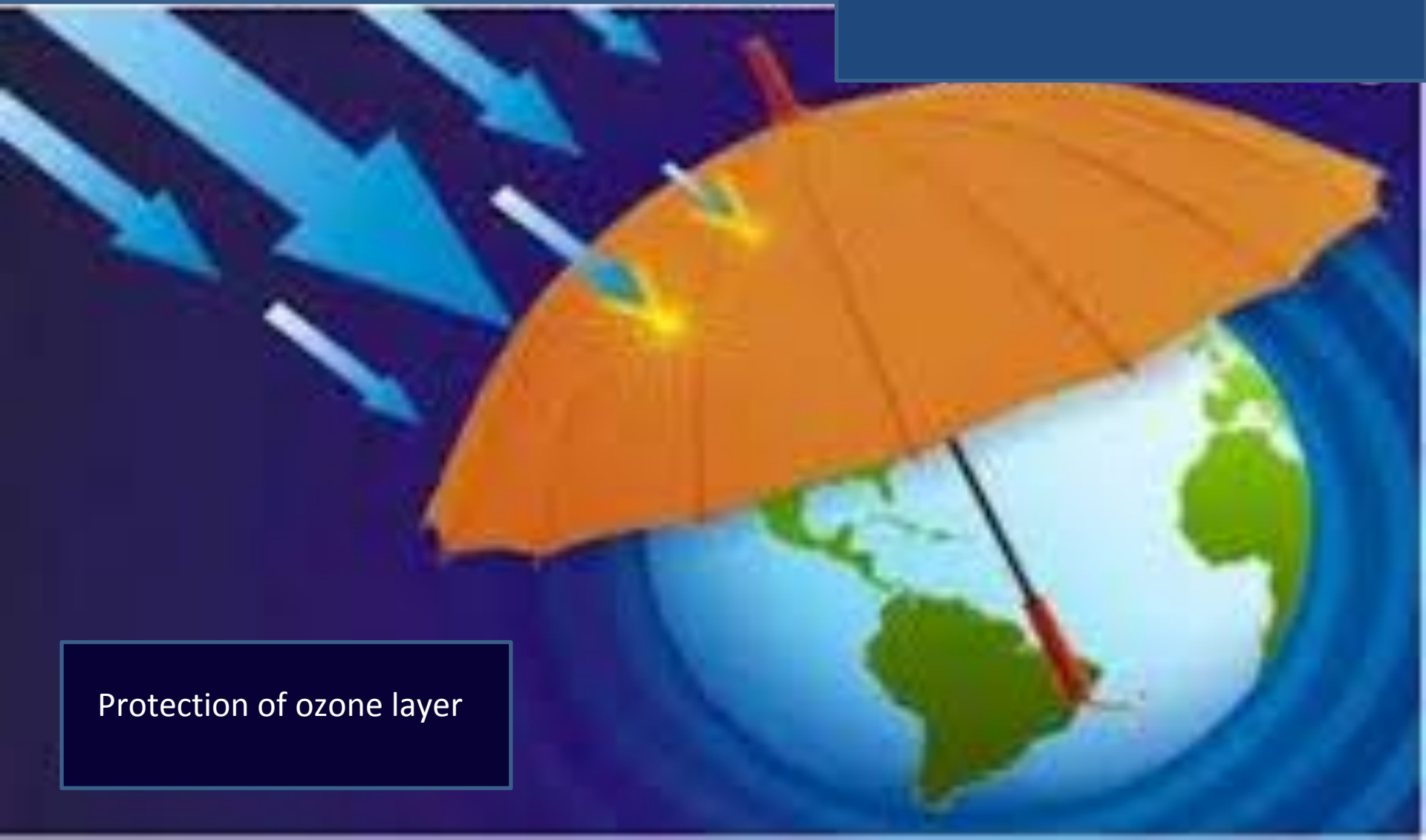
The second layer (from the ground) of the atmosphere (i.e., Stratosphere) is known as Ozonosphere. The concentration of Ozone gas is maximum here and so it is called **Ozonosphere**.


EXOSPHERE
10,000 km
THERMOSPHERE
700 km
MESOSPHERE
80 km
STRATOSPHERE
50 km
TROPOSPHERE
12 - 18 km

Functions of Ozone layer

Most ozone resides in the stratosphere (a layer of the atmosphere between 11 and 50 km above us), where it acts as a shield to protect Earth's surface from the sun's harmful ultraviolet radiation. With a weakening of this shield, we would be more susceptible to **skin** cancer, cataracts and impaired immune systems.

Ozone layer acts like an Umbrella



Protection of ozone layer

Chemistry of Ozonosphere

Ozone forms a layer in the stratosphere, thinnest in the tropics (around the equator) and denser towards the pole. The unit which is used to measure the amount of ozone present in a particular area is known as Dobson unit (Du) [1Du = 0.01 mm of the compressed gas at and 760 mm of Hg pressure].

Ozone layer is created when U.V radiation (sunlight) strikes the stratosphere. This U.V radiation dissociates oxygen molecules to atomic oxygen (O). The atomic oxygen quickly combines with other oxygen molecules (O_2) to form ozone.

Ozone forms the protective layer around the earth

The following reactions are known as "Chapman reaction".

$$O_2 + h \rightarrow O + O \quad \ldots (1)$$

$$O + O_2 \rightarrow O_3 \quad \ldots (2)$$

Although the U.V radiation splits the O_3 molecule but it reforms again, resulting in no net loss of ozone.

$$O_3 + h \rightarrow O_2 + O \quad \ldots (3)$$

$$O + O_2 \rightarrow O_3 \quad \ldots (2)'$$

Ozone is also destroyed by the following reaction

$$O + O_3 \rightarrow O_2 + O_2 \quad \ldots (4)$$

As height increases, rate of dissociation of O_3 molecules increases and rate of formation of the same decreases. The concentration of ozone is a balance between these competing reactions. In this way a layer of O_3 molecule forms in stratosphere. As the layer thus formed in stratosphere by following the above mentioned reactions, is sometimes called as the '**Chapman layer**'.

Pollution of Ozonosphere

Due to man activities ozone concentration in atmosphere had been on decrease. Many methods were suggested to overcome this problem. It has been reported recently that due to these corrective measures concentration of ozone has once again started increasing in upper atmosphere and may reach up to its optimum level.

Destruction of Ozonosphere (formation of Ozone hole)

Over **Antarctica**, stratospheric ozone has been depleted over the last 15 years at certain times of the year. As a result, the density of O_3 molecule in that particular region becomes very less and the U.V ray can easily penetrate that region and fall on the surface of the Earth. This particular region is known as '**Ozone hole**'.

Mechanism of Formation of Ozone hole

The formation of ozone hole depends on mainly the weather condition of the stratosphere. The following steps are involved in the formation of ozone layer-

i) During the **winter polar night**, sunlight does not reach the South Pole. A strong circumpolar wind develops in the middle to lower stratosphere. These strong winds are known as the '**Polar Vortex**'.

ii) Since there is no sunlight, the air within the polar vortex can get very cold. When temperature falls down below a special type of cloud is formed. This cloud is known as '**polar stratospheric cloud**' **(or PSC)**.

iii) Once, the PSC form, **heterogenous chain reactions** take place and convert the **inactive chlorine** (or bromine) **present in the stratosphere to more active form**. Here, chlorine (or bromine) is available from the chemicals released by human activities (such as **CFC**, compounds containing etc.)

iv) Ozone loss does not take place until **sunlight returns** to the air inside the **polar vortex** and allows the production of **active chlorine** and initiates the **ozone destruction cycle**.

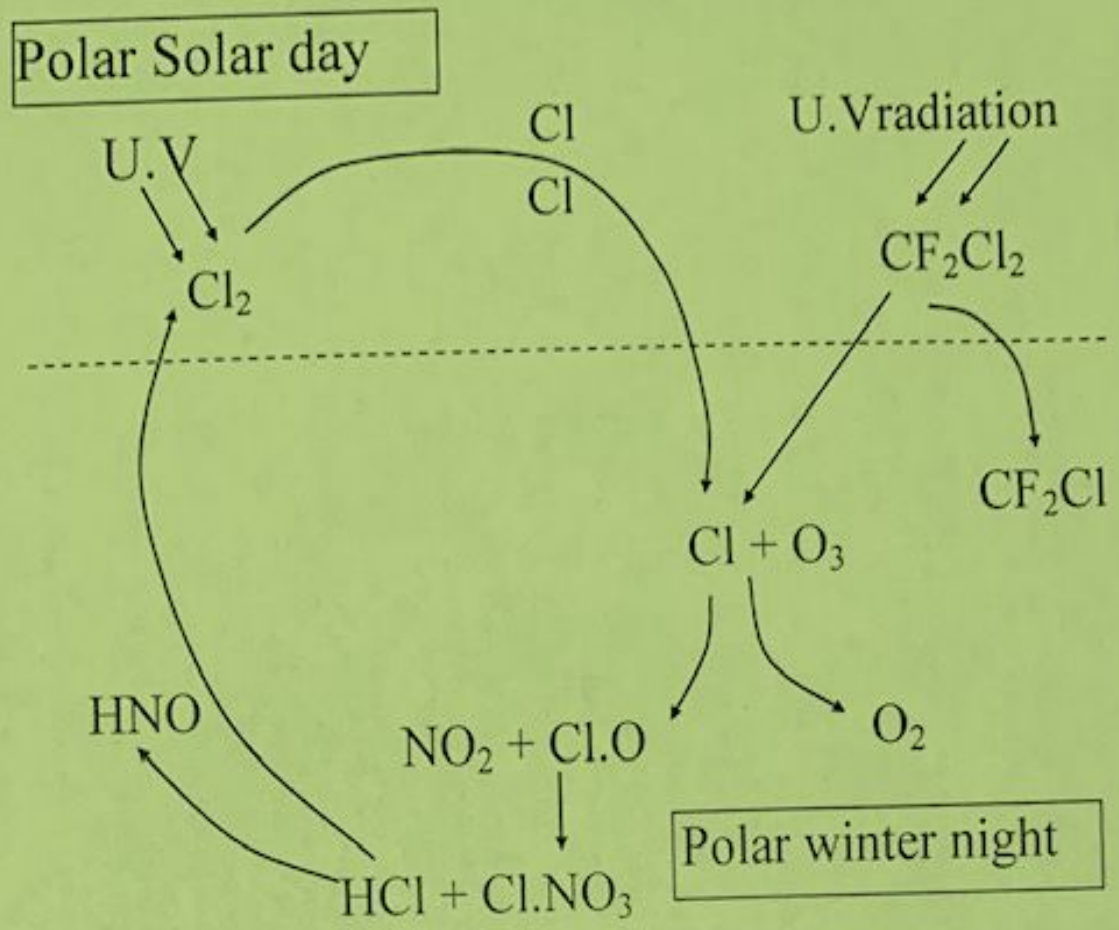
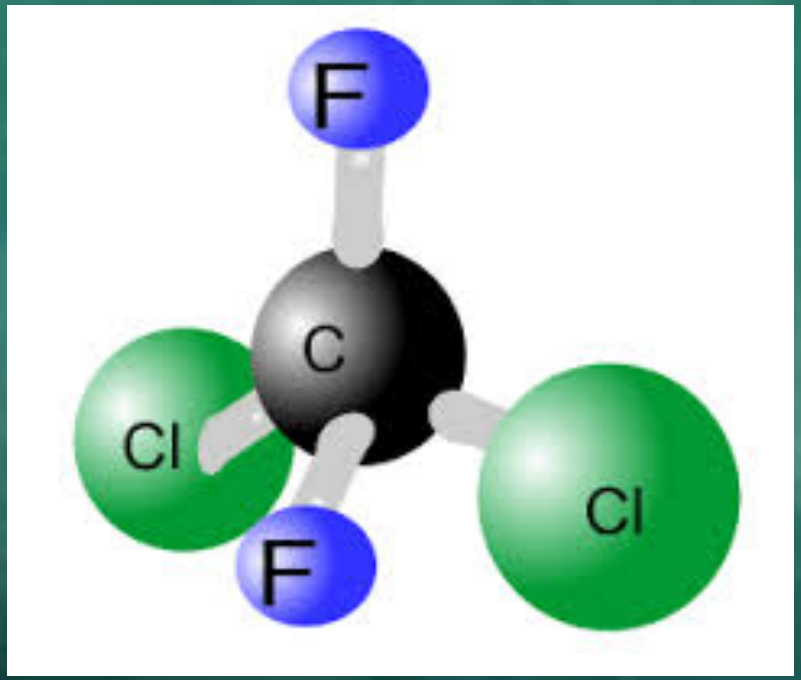


Fig: Depletion of O_3 molecule

Adverse Effect of Formation of Ozone Hole

- U.V penetrates the ozone layer and fall on the surface. This ray is responsible for skin cancer called “Melanoma” and other diseases.
- This ray also disturbs the immune system of the living body.
- U.V. rays cause cataract in the eyes.
- This ray is also responsible for the retardation in the plant growth.
- This U.V rays which is coming through the ozone hole, is responsible for the global warming too.

Chemistry of ChloroFluoroCarbon (CFC)



Definition

A hydrocarbon, in which some or all of the hydrogen atoms have been replaced by chlorine and fluorine, is called Chlorofluorocarbon (CFC). These compounds are used as a feedstock, as a refrigerant, as a solvent and as blowing agent of plastic foam.

Types of Chlorofluorocarbon (CFC)

There are four different types of CFC –
Chlorofluromethane: These are derived from the methane. e.g. etc.

Fully halogenated CFC: This type of CFC contains only halogen like fluorine, chlorine and carbon.

Hydrochlorofluoro carbon (HCFC): CFC contains hydrogen along with chlorine, fluorine & carbon, called hydrochlorofluoro carbon.

Hydro fluorocarbon: CFC contains no chlorine, called hydro fluorocarbon.

Alternative to CFC

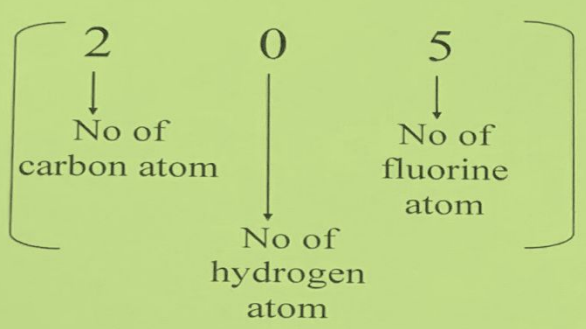
Hydrochlorofluoro carbon (HCFC) and hydro fluorocarbon (HFC) are the alternative to fully halogenated CFC. Because it has the environmental advantage that, due to the hydrogen bond, they are less stable in atmosphere and hence, are less likely to reach the stratosphere to affect the ozone layer. Its ozone depletion potential is of that for the most commonly used CFC.

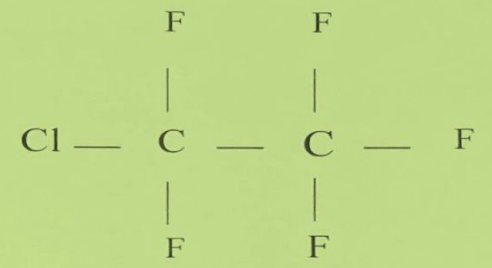
Halocarbon Numbering System

The halocarbon compounds like, CFCs, HCFCs, HFCs are referred to using a number system developed by DuPont. For example, trichlorofluromethane, is CFC-11 and the hydrochloroflurocarbon CHF_2Cl is HCFC-22 .

To determine the chemical formula from a fluro carbon number, begin by adding 90 to the number and then interpret the three digit result as follows: the left most digit is the number of carbon atoms, the middle digit is the number of hydrogen atoms and the right digit is the number of fluorine. The remaining valences of the carbon atoms of the halocarbons are satisfied by the chlorine atoms.

CFC–115: Adding 90 with 115 gives 205. Thus, a molecule contains two carbons, no hydrogen and five fluorine atoms. The remaining sites of carbon are occupied by chlorine atoms.





The chemical formula would be therefore be: C_2ClF_5 (or CF_3CF_2Cl).

CCl_2FCClF_2 has two carbons, no hydrogen and 3 Fluorine. So, CFC number is 203. Subtracting 90 from 203 gives (203 – 90) = 113. So, the compound is numbered as **CFC – 113**.

The halons also have a numbering system, but this one is not so complicated. Halons are given a four digit designation, with the leftmost digit begin the number of carbons. The second is fluorines, the third is chlorines and the fourth is bromines.

Montreal Protocol

It is an international agreement, signed in 1987 at Montreal, to stop the production of Ozone Destroying Substances (ODS) like CFC etc. by the year 2000.


THANK
YOU