

## How Greenhouses Work

Greenhouses create an artificial environment, sheltered from the "outside" environment that may be too cold, too hot or too variable for the growing of plants. Greenhouses use their glass enclosures to trap solar radiation; the radiant heat enters through the glass or plastic covering and warms the air, soil and plants inside. This warm air rises and is replaced by cooler air that in turn is warmed up; this cycle raises the temperature quickly. The heat created by the solar radiation, plants and from the soil is "trapped" by the glass. Sometimes, the air inside can be overheated and has to be vented out. As you drive by a greenhouse, you may see the glass panels on top open to vent out the warm air vertically. Venting can also occur horizontally through side fans and vents. The venting also keeps the air in the greenhouse moving, allowing for a more even temperature throughout and cycling the carbon dioxide that plants need to grow. Most modern greenhouses have automated systems to regulate the temperatures inside.

The "heat" which is generated often comes from the sun. However, in really cold climates, heat is added to the air or to the soil.

In addition to the "heat component", plants in greenhouses also require water. Many greenhouses use an automated irrigation system to keep the growing media moist and flowering plants supplied with needed water. Hydroponic systems, that don't use soil to "hold" moisture, supply water directly to the roots on a more frequent basis.

Although a greenhouse may appear to be a simple structure, the key components of any human-made structure are present; in a greenhouse, these include ...

- a strong foundation,
- a sturdy frame to maintain the glass (or plastic) panels,
- flooring that varies from simple dirt to concrete, wood or stone,
- "glazing" - glass or other synthetic covering to allow in solar radiation and to help to provide insulation,
- a system for watering of the plants and flowers.

## Life Support Systems

In human history, humans moved from a “hunting and gathering” nomadic life to become inhabitants of a fixed place with the cultivation of plants and the domestication of animals – the beginning of agriculture. The basics of life support – air and water – are provided by the Earth’s ecosystem.

### In the past ...

However, humans have learned to “modify” small portions of the Earth’s biosphere with the creation of GREENHOUSES. It is speculated that the earliest greenhouses may have been developed in ancient Rome, nearly 2000 years ago ... to grow vegetables year-round for the demanding Roman emperors! At this point, glass had not been invented, so small sheets of the mineral mica were used.

In the 13th century, greenhouses were built in Italy to grow the exotic plants that explorers brought back from the tropical areas that they visited.

In the 17th century, the first greenhouses made with glass emerged in Europe to propagate tropical plants in the colder environment of the area. Later, greenhouses for people evolved (called solariums), to provide warmer environments for human habitation.

Greenhouses may have been developed in the Far East in the 15th century, in both China and Korea. In Korea, greenhouses were used to grow mandarins using an active soil heating system.

The concept of greenhouses also appeared in Netherlands and then England in the 17th century. Today, the Netherlands has many of the largest greenhouses in the world, some of them so vast that they are able to produce millions of vegetables and flowers every year.

The botanist Charles Lucien Bonaparte may have built the first practical modern greenhouse in Leiden, Holland during the 1800s to grow medicinal tropical plants. In France, greenhouses were used to grow both oranges and pineapples, plants that could not withstand the harsh climate of northern Europe without some form of modification.

An elaborate greenhouse was built to accompany the Palace of Versailles just outside of Paris in the 17th Century; it was 150 metres by 13 metres and exceeded 14 metres in height.

At the same time, in the United Kingdom, elaborate greenhouses were established including several in Key Gardens and The Crystal Palace.

In the 20th century, the geodesic dome was added to the many types of greenhouses including the Eden Project in southwest England, and the Climatron in the Missouri Botanical Gardens in St. Louis.

The availability of polyethylene (the most common form of plastic) as a replacement for glass was one of the main developmental features of the late 20th century. The early versions of polyethylene did not stand up to the UV rays of the sun very well; however, their durability was increased with the development of effective UV-inhibitors in the 1970’s and 1980’s.

In recent years, greenhouses with two or more connected bays have been developed; they use a common wall or a row of support posts. Most of the greenhouses in Southern Ontario are in this form.

### In the future ...

Because of the lack of a suitable biosphere on either the Moon or Mars, the habitants of these new environments will have to create their own! This will be a CLOSED life support system that includes plants and microorganism – a greenhouse on Mars. A greenhouse isolates plants from the adverse conditions of the Martian environment.

## The Martian Environment Compared to Earth's Environment

COMPONENT	MARS	EARTH
Atmosphere components	95% Carbon Dioxide	77% Nitrogen, 21% Oxygen, .038% Carbon Dioxide
Atmospheric Pressure	7.5 millibars (average)	1013 millibars (average)
Gravity	0.375 of Earth's gravity	2.66 times the gravity of Mars
Distance from the Sun (average)	228 million km	150 million km
Relationship with the Sun	Thin atmosphere - high levels of radiation	Earth's atmosphere is similar to a greenhouse - blocking radiation and moderating temperatures
Surface Temperature AVERAGE	-63°C	14°C
Surface Temperature RANGE	-12°C to +20°C	-88°C to +58°C
Surface Temperature DAILY RANGE	Daily range - 100 Celsius degrees	Daily range - usually less than 30 Celsius degrees
Surface Material	No organic material - mostly silicon dioxide, iron oxide and "rocks" similar to those on Earth; no permanent surface water	Varies with region - soil contains both organic and inorganic materials.

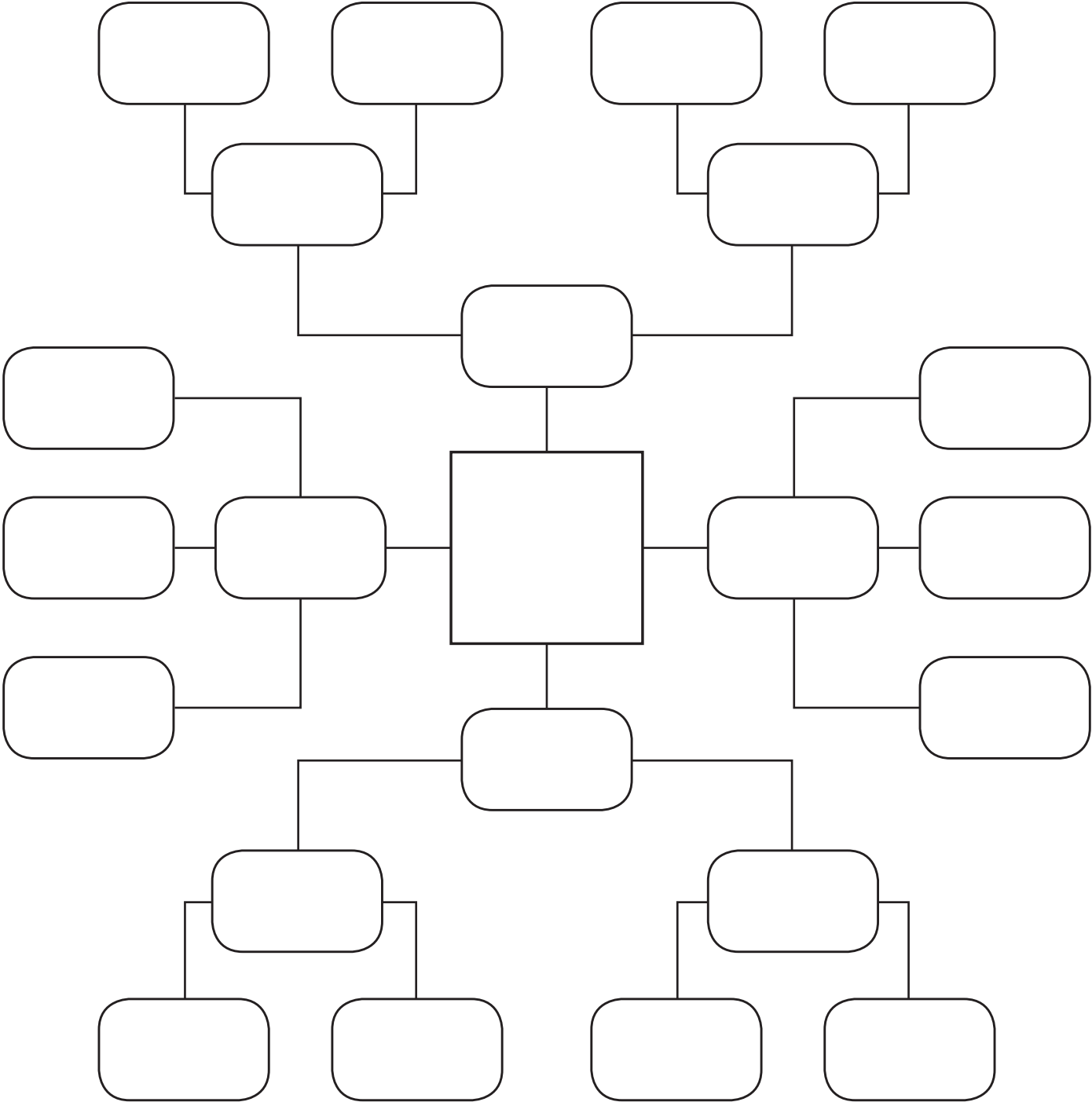
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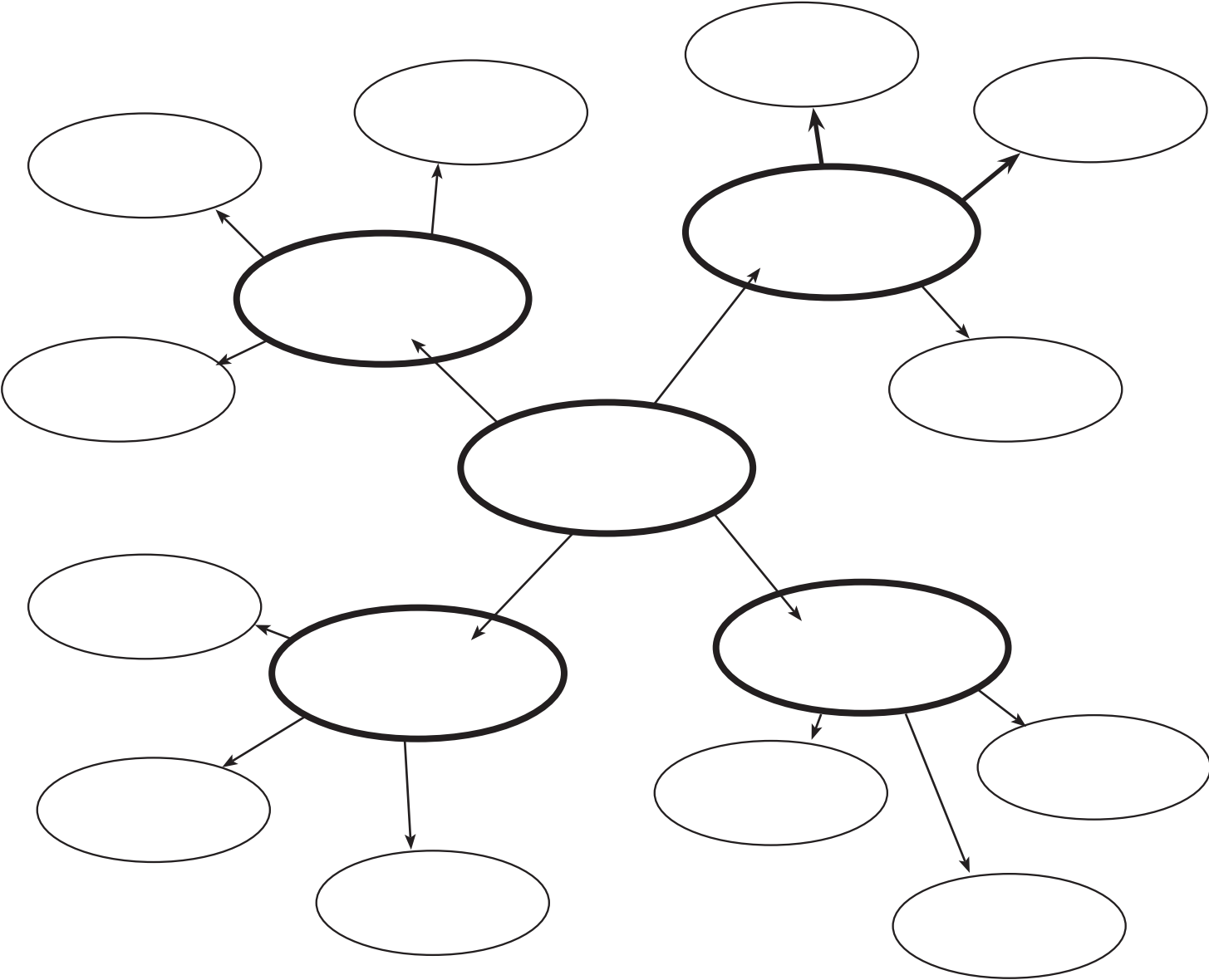
# Technology in the Greenhouse

Level of Technology	Advantages	Disadvantages
High - Using machinery and robotics wherever possible		

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# Building a Greenhouse on Mars

List in order, the things that need to be done before actually growing plants	Provide reasons for your order