WATER SYNTHESIS FROM CHEMICAL

AND

ORGANIC PROCESSES

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Unbeknownst to him, of all the things Man makes he is above all, a Watermaker.

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WATER OR FROZEN CO_2?

In Space-related circles, there is much excitement and debate over whether the glassy regoliths at the north and south poles of the Moon are water ice or frozen carbon dioxide. There are also many initiatives currently underway by space entities who've built robotic devices to excavate these structures. Until this issue is resolved, there exists a need to develop technologies which address how one would make water, H_2O. It is a contingency strategy to fall back on in the event the formations turn out to be merely frozen carbon dioxide. The purpose of this paper is to describe the research findings of Xybex Water R&D, Inc. whose objective is to focus on developing support systems for human survival on planetary bodies, such as the Moon and Mars. It is always advantageous to land on a planetary body, for example, any of the 61 moons discovered in the solar system to date, since mineral rocks can serve as a natural resource. Lead (Pb) tiles and refractory glass can offer protection from radiation in any habitat. Building homes, restaurants, and farms on the Moon and Mars are no longer out of the reach of mankind.

One of the most important axioms of Organic Chemistry as it relates to hydrocarbons must be stated at the outset: **Water and CO_2 are the end products of the complete combustion of organic compounds, including fossil fuels.** Combustion occurs in the presence of Oxygen (O_2), as when one lights a match. The simplest of these is the hydrocarbon, methane, or cooking gas:

Methane	$CH_4 + 2\ O_2 \rightarrow CO_2 + \mathbf{2\ H_2O}$
Ethane	$C_2H_6 + 3.5\ O_2 \rightarrow 2\ CO_2 + \mathbf{3\ H_2O}$
Propane	$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + \mathbf{4\ H_2O}$
n-Butane	$C_4H_{10} + 6.5\ O_2 \rightarrow 4\ CO_2 + \mathbf{5\ H_2O}$
n-Pentane	$C_5H_{12} + 8\ O_2 \rightarrow 5\ CO_2 + \mathbf{6\ H_2O}$
n-Hexane	$C_6H_{14} + 9.5\ O_2 \rightarrow 6\ CO_2 + \mathbf{7\ H_2O}$
n-Heptane	$C_7H_{16} + 11\ O_2 \rightarrow 7\ CO_2 + \mathbf{8\ H_2O}$
n-Octane	$C_8H_{18} + 12.5\ O_2 \rightarrow 8\ CO_2 + \mathbf{9\ H_2O}$

n-Nonane $C_9H_{20} + 14\ O_2 \rightarrow 9\ CO_2 + \mathbf{10\ H_2O}$

n-Decane $C_{10}H_{22} + 15.5\ O_2 \rightarrow 10\ CO_2 + \mathbf{11\ H_2O}$

Unfortunately, water vapor is an invisible vapor, in much the same way electrons, protons, bacteria and viruses are invisible to the eye; yet we know they exist. The vapor is visible when it condenses to droplets on cooled glass, or when various condensation devices such as air conditioners, dehumidifiers, cooling coils or freon based coolants are used to condense the vapors into water droplets. If one thinks of all the combustion processes which occur on a daily basis, cooking, driving, hot water boilers, industrial smelting processes, etc., one would understand that the earth can be likened to a fishbowl, it just fills up with water unless some of it is removed. Hence, there is NO LIMIT to the amount of water which can be bottled and shipped to the Moon, Mars, and other planetary bodies. CO_2 can be used as a refrigerant (dry ice) and as a greenhouse gas, producing instant forestation. And now with the advent of synthetic gasolines, water is directly recoverable from hydrocarbon combustion processes, as these synthetic gasolines are clean burning fuels, free of exhaust contaminants like sulfur dioxide and lead. Water reclaimed from hydrocarbon combustion is suitable for personal cleansing, washing, gardening, even in shellfish aquariums. Filtration with polymer materials, sand, distillation or activated charcoal can be used if necessary; corona-generated ozone is considered to be superior to other water treatment methods and is covered under the heading of "Water Treatment". How to recover the water formed from hydrocarbon combustion is covered under the heading, "Condensation Techniques". A significant amount of water and CO_2 are removed by the lungs during respiration, in the form of gaseous water vapor in one's breath; in order to capture this as water, air conditioners/dehumidifiers should be utilized to condense the gaseous vapor to water droplets. Hence, the more people working, cooking and exercising in a common area, the more water vapor will be available to be condensed.

A planned expedition of any size would require that at least 1 month's supply of bottled water be loaded on the spaceship; gas stoves, heaters, solar panels, juice machines, as well as a small scale FT-reactor (or some other means of making fuels) and an ozone generating machine. Sugarcane tops, corn, sugarbeet and grass seeds must be brought along, amongst other seeds. Although Mars appears daunting, its cyclic windstorms can be avoided by building living quarters underground. And, Mount Olympus, renowned as being one of the largest volcanoes in the solar system, can offer earthlings protection from the elements, once excavated, using robotic devices outfitted with jackhammers, drills and the like.

THE FISCHER-TROPSCH PROCESS

The Fischer-Tropsch process is a chemical process which was developed in Germany during WWII to make synthetic gasoline and is named after its inventors, Franz Fischer and Hans Tropsch. What's interesting about this process is that with *COBALT* catalysts in particular, for every barrel of synthetic gasoline produced, **1.1 barrel of *water* is produced as a byproduct, making it a regenerative system.** The inputs are Carbon Monoxide and Hydrogen, with some oxygen added in the POX, or Partial Oxidation process. SASOL is the most successful implementor of this technology, it is a firm based in South Africa which currently produces in excess of 150,000 barrels per day, and it is publicly traded under the NASDAQ stock symbol SASOY. Exxon, Royal Dutch, Syntroleum and Rentech have had similar successes. We wish to exploit this technology for two obvious reasons: Water and Synthetic Oil. *Burning hydrocarbons such as propane and butane produces water and* CO_2 *in significant yields*. Different fractionations to obtain a middle distillate product slate (propane, butane, pentane, heptane, hi-octane gasoline) can be achieved using Nickel catalysts, commonly referred to as hydrocracking.

Of all the different Fischer-Tropsch designs surveyed, www.fischer-tropsch.com, the most productive one is the Slurry Phase process. A Slurry Phase reactor is a vertical vessel in which the fine powdered cobalt catalyst is suspended in a bed of molten wax. The classic catalyst that has been employed since the inception of the Fischer-Tropsch methodology is *Magnetic Iron Oxide*, where for every barrel of synthetic gasoline produced, 7/10ths barrel of water is produced as a byproduct, making it a regenerative system, as the water can be recirculated to make more gasoline. However, the newest technologies use Cobalt catalysts, to obtain a broader slate of hydrocarbon products. It consists of pumping Synthesis Gas through a reactor vessel containing beads or "raneys" of activated **Cobalt** catalysts suspended in molten wax, called a slurry. Synthesis Gas (carbon monoxide and hydrogen) is fed into the bottom of the reactor and heated to 1,600 degrees F; the FT products emerge from the top and the side; the FT product is then cooled and condensed. The basic reaction to obtain **Propane** is: $3\ CO + 7\ H_2 \rightarrow C_3H_8 + 3\ \mathbf{H_2O}$. The general formulas are:

$n CO + m H_2 = C_n H2_{m-n} + n\mathbf{H_2O}$ (Fischer-Tropsch)

$3\ CO + 6\ H_2 = C_3H_6 + 3\ \mathbf{H_2O}$ (Fischer-Tropsch)

$CO + 2\ H_2 = CH_3OH$ (Methanol Synthesis)

$CO + 3\ H_2 = CH_4 + CO_2$ (Methanation)

$2\ CO + 2\ H_2 = CH_4 + CO_2$ (Methanation)

$3\ CO + 7\ H_2 = C_3H_7OH + 2\ \mathbf{H_2O}$ (Fischer-Tropsch)

The desired ratio of hydrogen to CO is 2:1 and it is this ratio which determines what catalyst, iron or cobalt, is to be employed. Adjustments can be made by adding CO_2 in the case of steam methane reforming in order to decrease the ratio from from 5:1 towards 2:1; if Partial Oxidation is used, steam may be introduced in order to raise the ratio towards the desired ratio of 2:1.

If cobalt is used as the catalyst, the products are hydrogen saturated paraffinic molecules. If iron is used as the catalyst, the products are a mixture of hydrogen saturated paraffinic and large volumes of hydrogen deficient olefinic and aromatic molecules and CO_2. The FT process can either be operated at high temperatures (HTFT), producing a light syncrude, or at low temperatures (LTFT), producing heavier, waxy hydrocarbons. The existing HTFT plants utilize circulating, fluidised bed type reactors operating at 300 - 350 degrees C, and 25 bar pressure. The LTFT plants utilize both the Arge process and Slurry Phase processes. The Arge Process is based on a tubular fixed bed reactor, operating between 180–250 degrees C, and pressures between 10 – 45 bar. The Slurry Phase Distillate Process was designed to produce middle distillate fuels such as high quality diesel, kerosene and some naptha. The production of hydrocarbons can be described as a polymer reaction; the reaction follows the Anderson-Schultz-Flory distribution. Liquified petroleum gas, propane, butane, fuel oil, illuminating parrafin, petrol, diesel and bitumen are also produced further downstream. Oxygenates in the aqueous stream are purified in the work-up plant to produce higher alcohols, acetic acid, and ketones, including acetone, ethyl ketone and methyl iso butyl ketone.

One of the limiting factors to the widespread application of this process was how to derive SynGas (Hydrogen and Carbon Monoxide gases) cheaply and in sufficient quantities. It was then discovered that this could be achieved either by “reforming” methane gas, or, through Partial Oxidation (POX). Reforming simply refers to the process of combining steam with methane gas over a Nickel catalyst to release CO and $H_{2;}$ large quantities of steam and the natural gas feedstock are pumped through tubes filled with the nickel catalyst. These tubes lead to another series of hollow Magnetic Iron Oxide tubes inside the shell of the reactor vessel and this mix of solid catalyst, natural gas, and steam is kept heated to 1600 degrees F by a series of burners outside the tubes, in the firebox of the reactor’s furnace.

In POX, a small amount of steam is pumped into the SynGas reactor. *Oxygen* is also introduced and this causes oxidation that gives off a tremendous amount of heat, in excess of 2000 degrees, hence no external burners are required. POX is a more versatile process as it can handle various feedstocks such as natural gas, coal, bitumen, coke, resid, biomass, etc. Steam reforming can only be applied to natural gas that has no sulfur as sulfur can poison the catalyst.

Methane gas can be synthesized through the anaerobic fermentation of biomass (spent sugarcane stalks, organic waste, etc.) with *green grass*. Biomass is combined with green grass/leaves/green agricultural waste in a closed container for 1 week at room temperature, the warmer it is, the faster it composts to produce methane gas. When there is inadequate oxygen, carbon monoxide forms from the *incomplete* combustion of hydrocarbons; carbon monoxide is also obtained from burning wood, from incineration processes and from steaming coal.

With Partial Oxidation, or POX, the amount of oxygen that is allowed to react with the natural gas or other carbonaceous feedstock is limited, or controlled. The amount of oxygen has to be controlled because the objective is to convert the feedstock to hydrogen and carbon monoxide. If too much oxygen is added, the mix shifts towards an excess of carbon dioxide instead of an excess of carbon monoxide.
The following table illustrates the typical SynGas ratio from each of these processes:

	H_2	CO	CO_2	Total
Steam Reforming	75	15	10	100
Partial Oxidation	62	35	3	100
Autothermal Reforming	34	17	2	53*

*Difference of 47% is nitrogen Source: Syntroleum

During combustion, the higher the octane fuel used, the more water vapor and CO_2 will be produced. Water vapor from fuels synthesized by the Fischer-Tropsch method does not contain contaminants, like sulphur dioxide, lead or other known exhaust chemicals from petroleum (fossil based) products. All Fischer-Tropsch fuels are clean-burning fuels, which is why the water recovered from combustion of these fuels is pure water, and is suitable for washing, irrigation and farming. With filtration or distillation it can also be used in aquariums for aqua-culturing purposes. Most of the SASOL plants in place today make use of magnetic iron oxide catalysts. They are installed in the reactor as a group of hollow tubes, the number of tubes varies depending on the reactor size. Synthesis gas is fed in from the top of the reactor and the FT products appear at the bottom. Regardless of which technology is used, on planetary expeditions, scaled down models should be built to produce 200 to 500 barrels per day instead of a full scale implementation capable of 150,000 barrels per day, as the reactor must be loaded on the spaceship.

It is important to note the distinction between the water which is produced as a byproduct of the FT process and the water which is recovered during combustion of the hydrocarbon products. Water produced as a *byproduct* of the FT process is tainted and is not potable, it should be recirculated to make more SynGas, eliminating the need to constantly supply fresh water during the steam reforming phase. Whereas, the water recovered during *combustion* of the hydrocarbon products, i.e. cooking with propane gas, *is clean and should be condensed* for common use, utilizing an air-conditioner, dehumidifier, or some other condensation technique.

Hydrogen can be extracted from hydrogen compounds by passing the mixture over hot uranium metal.

Catalysts are available for purchase from The Activated Metals & Chemicals Group (subsidiary of the Celanese Hoescht Corporation, specializing in catalyst manufacturing). An ounce of Cobalt Catalyst costs about $400, quotes are based on market rates; the cost goes down as tonnage goes up. Their website is: **http://www.amcpmc.com**.

Recently, a one step approach has been used to obtain a selective product distribution, greater amounts of gasoline range and aromatical hydrocarbons. In a one step process, a shape selective acid catalyst such as HZSM-5 is combined with a FT catalyst. Olefinic and oxygenated products from FT synthesis are converted over the medium pore acidic zeolite HZSM-5 to aromatic gasoline-range hydrocarbons. The mixture of metal components has a large effect on the activity and selectivity because of the electrical interaction between metal species. Alloying of metals is expected to be effective in the precise control of selectivity in carbon monoxide hydrogenation.

The product distribution was shifted to the higher hydrocarbons by alloying of metals. The Cobalt-Nickel bi-metallic system supported on SiO_2 was found to be particularly suitable for catalytic gasoline synthesis because the catalyst was the most selective for formation of higher hydrocarbons as well as the most active for CO conversion.

Fischer-Tropsch COBALT Catalyst Design

1. Dissolve 246 grams of $Co(NO_3)_2$, $6H_2$ and 6.3 grams of $Th(NO_3)_4$ $4H_2O$ in 1300 cm^3 of H_2O.
2. Heat to boiling and add 100 grams of kieselguhr and 6 grams of MgO in 500 cm^3 of H_2O, maintaining the boiling.
3. Dissolve 92 grams of sodium carbonate in 500 cm^3 of H_2O and heat to boiling.
4. Add the boiling slurry of kieselguhr (diatomaceous earth, mainly silicon dioxide) and MgO to the carbonate and nitrate solutions simultaneously, stirring vigorously. Filter and wash with distilled water until free of sodium ions.
5. Dry the filter cake in an oven at 110° C overnight. Crush to 8-12 mesh. Heat the catalyst in a furnace in a stream of hydrogen, reaching 400° C in 2 hours. Hold at 400° C for 2 hours.

Nickel Oxide Alumina for Hydrogenation and Methanation

1. Dissolve 454 g. of $Al(NO_3)_3$ $9H_2O$ in 3000 cm^3 of H_2O and cool to 5-10°C. Dissolve 200 g. of NaOH in 1000 cm^3 of H_2O and cool to 5-10°C. Add the sodium hydroxide solution to the aluminum nitrate solution dropwise, while stirring vigorously over a period of 1-2 hrs.
2. Dissolve 100 g. of $Ni(NO_3)_2$ $6H_2O$ in 600 cm^3 of H_2O, add 45 cm^3 of concentrated HNO and cool to 5-10°C. Add the nickel nitrate solutions to the sodium aluminate solution with vigorous stirring over a period of .5-1 hrs.
3. Filter the light green precipitate in a Buchner funnel and suspend the filtrate in 2000 cm^3 of H_2O for 15 min. while stirring. Repeat the washing procedure six times. Cut the filtrate into cubes, place in an evaporating dish, and dry in an air oven for 16 hrs at 105°C. Crush the catalyst to 8-12 mesh.
4. Before use, the required amount of catalyst is reduced in a stream of hydrogen (30-80 $cm^3 min^{-1}$) for 16 hrs at 350°C. The furnace temperature is raised to the reduction temperature over a period of 3 hrs.

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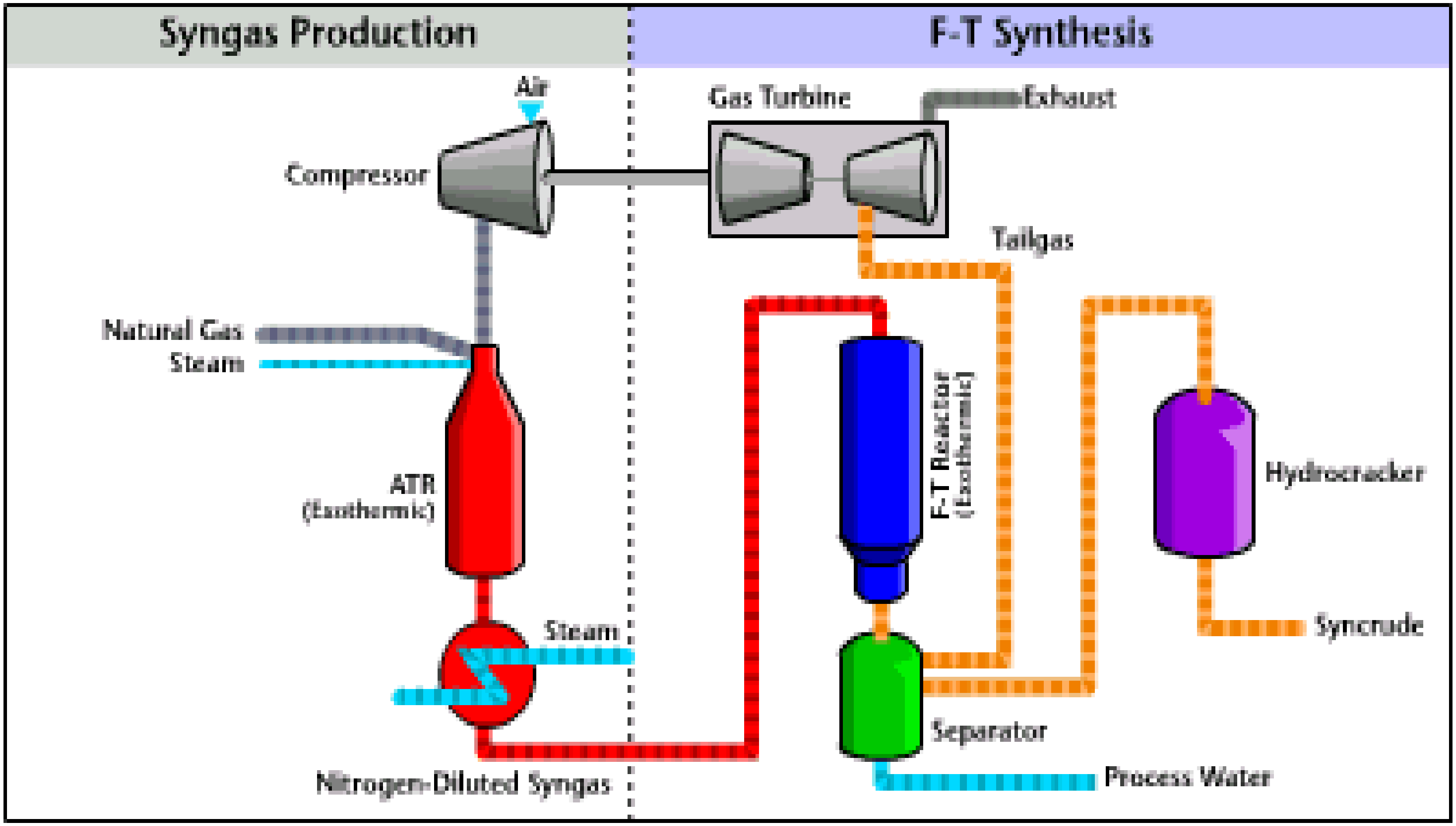
Syntroleum Corporation – Fischer Tropsch Reactor



WATER FROM RESPIRATION & METABOLIC PROCESSES

To reiterate, CO_2 and *water* are the two end products of all complete organic combustion processes and in this respect the human body can be likened to an automobile's combustion engine. Through respiration, sucrose is converted to blood glucose and this in turn is broken down through a complex set of more than 50 chemical reactions to provide us with energy; O_2 is supplied to the tissue by red blood cells which contain the O_2 carrier, hemoglobin. We exhale the CO_2 and excrete the *water*. This is a very difficult concept to grasp because one would tend to confuse the refreshment which was ingested with lunch as the water which is excreted a few hours later. What actually occurs is that the carbohydrates are metabolized in the presence of oxygen, producing *water*, CO_2 and energy; this process is fully explained and documented under the Krebs Cycle.* *The water is excreted as sweat or urine and the* CO_2 *is exhaled. A significant amount is exhaled as gaseous vapor in our breaths, especially during strenous activities such as working, running, and exercising, which is why air conditioners and dehumidifiers can be effective tools in condensing water vapor to droplets. The more people breathing, working, and exercising in an enclosed space or common area, the more water vapor there is to be condensed.*

Simple sugars and starches:
$C_6H_{12}O_6$ + 6 Oxygen → 6 CO_2 + **6 H_2O +** energy (36 ATP)

Table Sugar (sucrose):
$C_{12}H_{22}O_{11}$ + 12 Oxygen → 12 CO_2 + **11 H_2O +** energy

Vegetable Oils:
$C_{57}H_{104}O_8$ + 79 O_2 → 57 CO_2 + **52 H_2O +** energy

Vegetables and grains:
$C_6H_{10}O_5$ + 6 Oxygen → 6 CO_2 + **5 H_2O +** energy

Proteins:
Proteins + Oxygen → CO_2 + **H_2O** + *urea* + energy.

The application would be to open a sugarcane, sugarbeet and corn plantation on the Moon and on Mars, to start. All organic wastes would be returned to the sugarcane fields and the cycle would begin again. The Sugar Cycle is initiated when one plants sugarcane, sugarbeets and corn; the sugarcanes and beets are harvested and pressed into juice; the corn is harvested to make vegetable oil; all organic waste is used to irrigate and fertilize the fields and the cycle renews itself. Besides quenching thirsty palates, we can obtain brand new water simply from ingesting sugarcane and sugarbeet juice. Gram for gram, sugarcane and sugarbeets are the most efficient water generating foods known to man since, during respiration, sucrose and vegetable oils give off 11 and 52 grams of water, respectively. Raw fruit and fruit juices naturally contain fructose and water, as does

sugarcane juice. *Note that we are not concerned with processing sugar into crystals or granules, it is the juice we are after as the juice can naturally provide us with water and sucrose.*
Note: Energy is provided by the cellular production of ATP (adenosine triphospate), it is the main agent responsible for generating the electrical impulses which cross the neural synapses resulting in a powerstroke, or muscle movement.

Note: Although Organic waste is a very effective fertilizer, care must be taken to dilute concentrated urine with water when working with seedlings. It is recommended that you add one part urine to 3 parts water daily. For example, in a 60-day growing cycle, during the first 20 days, the amount of urine to be added is ¼ (1/4 urine, 3/4 water), during the next 20 days, it makes up 1/3 (1/3 urine, 2/3 water), and during the latter 20 days, it can make up ½ to ¾ of the solution applied (1/2 urine, 1/2 water), and with an extended growing cycle, ¾ urine to ¼ water. With young plants, watering in the early morning or dusk is best to avoid leaf burn due to intense sunshine at noon. Manure can be applied once every 5 days. Wearing helmets with oxygen can serve to protect one when dealing with waste.

Mature trees, mature fruit trees and mature foliage (shrubs, etc) can be fertilized directly, that is, organic wastes need not be diluted with water first, they can be applied directly. The rule of thumb is to always use a diluted solution with seedlings, very young plants, or new cuttings only. Once they are growing well, organic waste can be gradually added as fertilizer.Grafting techniques, to graft fruit trees, will be scanned and uploaded to the www.xybex.50megs.com website, which is currently still under contruction. Techniques for growing root vegetables will also be available on this site. As of this writing, funding is being sought to establish an international Seed Bank to load samples of every known vegetable and fruit seed on each planetary expedition. Any suggestions or contributions should be forwarded to xybex_research@usa.net.

Transpiration is the evaporation of water into the atmosphere from the leaves and stems of plants. Plants absorb soilwater through their roots and this water can originate from deep in the soil. (For example, corn plants have roots that are 2.5 meters deep, while some desert plants have roots that extend 20 meters into the ground). Plants pump the water up from the soil to deliver nutrients to their leaves. This pumping is driven by the evaporation of water through small pores called "stomates", which are found on the undersides of leaves. Transpiration accounts for approximately 10% of all evaporating water.

The Krebs Cycle: Human Respiration

The steps of aerobic cellular respiration involve the removal of hydrogen atoms and the release of CO_2; free oxygen is the final acceptor of the hydrogen atoms. *The oxygen combines with the hydrogen, forming water.* Aerobic respiration begins with an anaerobic stage in which glucose is converted to pyruvic acid, and there is a net output of 2 ATP per glucose molecule, referred to as glycolysis. In the subsequent aerobic stage, the pyruvic acid enters the mitochondrion, where it is further oxidized to form 34 ATP molecules. *Free oxygen acts as the final acceptor of the hydrogen released by the oxidation reactions, forming water.* For a concise and interactive diagram, please refer to this site by clicking on "Krebs Cycle": http://www.stark.kent.edu/~cearley/pchem/Krebs/Krebs.htm?clkd=wm**.** If this doesn't work, use a search engine to find interactive charts. The enzyme has been isolated and identified by Dr. Krebs as Aconitase. The Krebs Cycle is sometimes referred to as the Citric Acid cycle.

PRODUCTION

An adjunct technology to consider is the production of ethanol from fermentation of wheat, corn, oats or barley; enzymes are used to convert the starch fraction to glucose and yeast is added to perform the fermentation. Generally speaking, the production of fuel ethanol comprises four main steps: (1) the treatment of the feedstock to form a sugar solution; (2) conversion of the sugar to ethanol and CO_2 by yeast or bacteria; (3) distillation of the ethanol from the fermentation broth, and; (4) dewatering of the ethanol (McCurdy, 1986). The actual production of ethanol, requires only the carbohydrate portion of the grain; the other materials, including protein, fibre, oil, ash and gum, are superfluous to the process. An array of technologies are used to produce the fuel ethanol. Discussions of the different processes are found in a number of publications including Mulligan (1993), May (1987), McCurdy (1986), Keim (1983), and Pomeranz (1973). Wayman and Parekh (1990) give detailed descriptions of ethanol production at three plants, including the St. Lawrence Starch Company. Flow diagrams for wet milling, dry milling and dry grinding processes can be found in Fairlie et al. (1994). Following isolation of the starch fraction, *enzymes are added to convert the starch to glucose. Yeast, generally Saccharamyces cerevisiae*, *is added to ferment the glucose to ethanol*. The ethanol is distilled from the fermentation broth leaving the stillage.

In the presence of sufficient oxygen, water and CO_2 are the end products of ethanol and methanol combustion.

A fermentation of great industrial importance is the acetone-butanol fermentation performed by the bacterium *Clostridium acetobutylicum*. This microorganism ferments sugars to form acetic and butyric acids, carbon dioxide, and hydrogen. In subsequent reactions this organism converts acetic acid to ethyl alcohol and butyric acid to butanol and acetone.

Isopropyl alcohol wipes can be used daily to cleanse the body and is an effective anti-bacterial agent.

NEUTRALIZATION OF CARBONATE SHELLS

Besides the Fischer-Tropsch method of making synthetic hydrocarbons, the synthetic production of Citric Acid is another great achievement of man. It is based on the use of the ***Aspergillus Niger mold*** (which can be purchased in the form of a culture) to produce Citric Acid in volume.
Xybex Water R&D, Inc. has taken it one step further by reacting Organic Acids with carbonates, calcium carbonate for example, *neutralizing* it and yielding: CO_2, ***water*** and calcium citrate, an absorbable form of calcium. This form of Calcium carbonate is found mainly in eggshells, clam shells, lobster shells, etc. as opposed to carbonate minerals from ore. We've developed a procedure to bottle this into a popular softdrink, by adding 4-6 tablespoons of sugar, somewhat like "Calcium-fortified Kool Aid", in all the popular flavors. It is well understood that calcium is necessary for healthy bones and teeth, especially in lower gravity environments. Neutralization occurs when an acid and a base are reacted, yielding *water* and a salt of the acid. Clams should be steamed and the shells should be pulverized into a fine powder using a *Pulverizer* before adding citric acid.

The application would be to open a Seafood Restaurant on the Moon, using the spent shells to make soda water (clam shells, conch shells, escargot/snail shells, crab shells, etc.). Shellfish aquariums can be set up with seaweed plants which take in CO_2 and give off oxygen. We could also open bakeries and use spent eggshells as input to this process. This has tremendous commercial viability. Note that ***Organic*** acids and not chemical acids are used in the ***Neutralization*** process. This is because chemical acids pose the danger of leaving residual caustic products in the water, hence only organic acids such as Citric, Tartaric (grapes), Benzoic (cranberries), Ascorbic, Tannic, and Acetic acids are used. At room temperature, the dissolution of the carbonate proceeds rapidly to equilibrium, and lab experiments are currently being conducted to determine whether endothermic or exothermic processes increase the solubility of calcium carbonate even more so. The basic equation is:

$$CaCO_3 + H_3C_6H_5O_7 \rightarrow Ca(C_6H_5O_7) + H_2CO_3 \quad \text{(Intermediate Step)}$$

$$\rightarrow Ca(C_6H_5O_7) + \mathbf{H_2O} + CO_2$$

The products on the right side of the equation are: Calcium Citrate, *water* and carbon dioxide.

Substituting other organic acids yields Calcium Ascorbate, *water* and carbon dioxide;

$$CaCO_3 + H_2C_6H_6O_6 \rightarrow Ca(C_6H_6O_6) + H_2CO_3 \quad \text{(Intermediate Step)}$$

$$\rightarrow \quad Ca(C_6H_6O_6) + \mathbf{H_2O} + CO_2.$$

And Calcium Tartarate, *water* and carbon dioxide respectively:

$$CaCO_3 + H_2C_4H_6O_6 \rightarrow Ca(C_4H_6O_6) + H_2CO_3 \quad \text{(Intermediate Step)}$$

$$\rightarrow Ca(C_4H_6O_6) + \mathbf{H_2O} + CO_2.$$

Yield varies in direct proportion to the amount of carbonates and acids used. Please note that it is not necessary to use synthetic acids if fruit juices are readily available, as nearly all fruits contain either malic/ascorbic/citric acids. For example, if grape juice is available then it will naturally contain tartaric acid and simply by adding 2 tablespoons of powdered eggshells, the process rapidly proceeds to equilibrium. On the other hand, natural fruit juices which are not acidic enough can be made so by the addition of synthetic citric acid (the more acidic the juice, the more hydrogen ions will be in the solution and the more successful the neutralization process). Natural litmus paper can be made by using red cabbage dye. If the litmus paper dipped in turns pink or red then the solution is acidic, if it turns purple, it is neutral, and if it turns blue or green, then the solution is basic.

It should be emphasized that if you set out to measure the amount of water obtained from this process, it would appear disappointingly minimal. However, this is deceptive, because when continued on a cumulative basis, it becomes a significant resource. The explanation for this is that since water is obtained from the dissolution of the carbonate, and since 4-6 tablespoons of sugar are added to make a softdrink, ***the total water obtained is the sum of the water obtained from respiration/metabolic digestion of the sugar plus what is produced from the dissolution of the carbonate***. When this water is excreted in the form of urine and transferred onto the sugarcane, sugarbeet and corn fields, it irrigates the fields and produces a greater yield of agricultural products each time. The more carbohydrates consumed -- vegetables, starches and sugar (fructose, lactose, sucrose, dextrose) -- the more *water* is produced from the respiratory cycle. This is a unique and naturally self-sustaining process. Sugarcane is propagated by cutting the tops off and planting them directly in soil.

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Dispensing Procedure

Plastic/glass refreshment dispensers can be used. The products, powdered carbonate shells and blended citrus fruits/citrus juice, blended tomatoes, or synthetic citric acid can be mixed in the dispensers and the calcium citrate precipitate can be filtered out after 3-4 hours. Too much carbonate can result in a chalky taste, therefore filtering is suggested if a large quantity of carbonates are used. Filtering can be achieved through the use of mesh filters, cheesecloth, or simply by draining the neutralized solution into another container/dispenser. 5-gallon water containers with dispenser attachments can also be used. It is important to add 4-6 tablespoons or more of sugar prior to serving the beverages. Dropping the eggshells into boiling water for 2 minutes kills any salmonella bacteria and breaks down the natural adhesive which cements the eggshell together. See Exhibit B.

Another method is to put the powdered carbonates in a large square of wet cheesecloth, wrap it loosely and tie it with a rubberband/string then drop the contents into the container, after 3-4 hours, the shells are removed simply by lifting the bundle out of the container. *The citric acid from the Calcium Citrate precipitate can be recycled/recovered by reacting it with sulfuric acid.*

Acetic Acid Production

Acetic Acid can also be used to neutralize carbonates yielding $\mathbf{H_2O}$ and CO_2. Acetic Acid is the basis of making vinegar, it is often diluted to 5% acidity by the addition of water. Natural vinegar is made by fermenting fresh fruit juice with some starter culture, covering it with cheesecloth and storing it in a warm, dark and well ventilated area. At this point, we would add a cup of powdered eggshells or other carbonate shells to release water into the concentrated acetic acid; the calcium acetate is then filtered out of the vinegar solution after 3 hours, to avoid a chalky residual taste. Add additional fresh water to dilute to 5% acidity. Powdering increases the reaction rate at which the carbonate shells dissolve, speeding up the neutralization process. Powdering is achieved by using a conventional coffee grinder. In the absence of this device, use a hammer/mallet to smash the carbonates into fine powder, a seed grinder is also effective.

Citric Acid Production

The fermentation procedure requires the use of cornstarch/potato starch/dextrose or an agar medium; well cooked rice can also be used as a fermentation medium, as well as molasses. The newest technology is referred to as Direct Fermentation: the ***Aspergillus Niger*** mold is submerged in cornstarch, without hydrolysis (no water is added), and after 100 hours, or approximately 4 days, citric acid is produced in volume.[4] The content of citric acid in the fermented mass is 180-200 grams/liter, with a 95% conversion rate. An alternate method is to submerge the mold in corn syrup or dextrose. The Aspergillus Niger culture is offered for sale by several companies via the Internet: www.nationwidescientific.com and www.nebraskascientific.com.

The recovery of the acid produced during fermentation is precipitated in the form of its calcium or barium salt (calcium citrate or barium citrate), then liberated from the salt using sulfuric acid and refined.

Chemical name: 2-hydroxypropane-1,2,3-tricarboxylic acid
Molecular formula: $C_6H_8O_7.H_2O$ or $C_6H_8O_7$
Molecular weight: 210.14 or 192.12

Physiochemical Specifications of Citric Acid Production:

Physical Appearance:	White to Off-White Crystals
Solubility (5% Water)	Soluble
pH (0.5% Solution)	2.0-3.0
Assay	99+%
Water (Karl Fischer)	<1.0%
Melting Point	155 C

Note: The chemical formula of each of the organic acids mentioned is:
Ascorbic Acid: $H_2C_6H_6O_6$.
Phosphoric Acid: H_3PO_4.
Tartaric Acid: $H_2C_4H_6O_6$. Occurs naturally in Grapes.
Malic Acid: Occurs naturally in green apples, peaches, plums, cherries and other fruits.
Benzoic Acid: Occurs naturally in Cranberries.

Esters

Artificial flavors, or esters, are synthesized by reacting a carboxylic acid with an alcohol, yielding an ester and water. Some produce pleasant odors like cherry, strawberry and banana flavors, while others do not. The general equation for esterification is:

$$\mathbf{RCOOH + R'OH \dashrightarrow RCOOR' + H_2O}$$

Esters made from alcohols and organic acids of low molecular mass are colorless liquids that have agreeable, fruity odors.

Esterification bears some resemblance to neutralization in that *water* is one of the products of the reaction. An important difference is that in neutralization, hydrogen ions and hydroxide ions combine to form water. In esterification, these ions do not exist.

To bring about esterification, the organic acid and alcohol are warmed in the presence of concentrated sulfuric acid, which acts catalytically. The sulfuric acid absorbs the water by forming the hydrate, $H_2SO_4 \cdot H_2O$. Removal of the water in this manner (water is a product of the reaction) drives the equilibrium to the right, favoring the formation of more ester.

Ester	Acid	Scent/Taste
Ethyl butyrate	Butyric	Pineapple
Ethyl formate	Formic	Rum
Methyl salicylate	Salicylic	Wintergreen
Octyl acetate	Acetic	Orange
Pentyl acetate	Acetic	Banana
Pentyl butyrate	Butyric	Apricot
Methyl anthranilate		Grape
Methyl butyrate	Butyric	Apple

DIRECT REDUCTION

In the field of Extractive Metallurgy, the use of air, or oxygen, in the blast furnace is a necessary step in quality steel production. Historically, Oxygen and CO_2 have been used by western civilizations as classic reducing agents. However, in certain countries, *hydrogen* gas is used as the reducing agent because hydrogen is readily obtained by reforming methane gas. All are reducing gases, but it is only with hydrogen gas that *water* forms as a byproduct. This process is referred to as "Direct Reduction", yielding cheap and fast batches of sponge, or gangue steel, which requires further processing. Therefore, Direct Reduction with Hydrogen gas of the class of oxides referred to as Metal Oxides yields *water* and free metal.

Iron Oxide:	$Fe_2O_3 + 3\ \mathbf{H_2} \rightarrow 2\ Fe + \mathbf{3\ H_2O}$
Copper Oxide:	$CuO + \mathbf{H_2} \rightarrow Cu + \mathbf{H_2O}$
Aluminum Oxide:	$Al_2O_3 + 6\ \mathbf{H_2} \rightarrow 2\ Al + \mathbf{3\ H_2O}$
Cadmium Oxide:	$CdO + \mathbf{H_2} \rightarrow Cd + \mathbf{H_2O}$
Lead Oxide:	$PbO + \mathbf{H_2} \rightarrow Pb + \mathbf{H_2O}$
Magnesium Oxide:	$MgO + \mathbf{H_2} \rightarrow Mg + \mathbf{H_2O}$
Strontium Oxide:	$SnO + \mathbf{H_2} \rightarrow Sn + \mathbf{H_2O}$
Tungsten Oxide:	$WO_3 + 3\ \mathbf{H_2} \rightarrow W + \mathbf{3\ H_2O}$

Reduction of Converted Carbonates

Reduction of Carbonates is a 2-step process. Heating Carbonate Minerals in air, or oxygen, is called calcining, and converts the carbonates to oxides giving off CO_2. In a subsequent step, hydrogen can be used to reduce the Calcium Oxide and Magnesium Oxide to their metals, giving off *water* vapor in the process.

Dolomite: $CaCO_3 . MgCO_3 + O_2 \rightarrow MgO. CaO + 2\ CO_2$ (Intermediate Step)
$CaO . MgO + \mathbf{H_2} \rightarrow Ca + Mg + \mathbf{H_2O}$

Reduction of Converted Carbonates (continued)

Other Carbonates:

Siderite	$FeCO_3 + O_2 \rightarrow FeO + 2\ CO_2$ $FeO + \mathbf{H_2} \rightarrow Fe + \mathbf{H_2O}$
Malachite	$CuCO_3 + O_2 \rightarrow CuO + 2\ CO_2$ $CuO + \mathbf{H_2} \rightarrow Cu + \mathbf{H_2O}$
Smithsonite	$ZnCO_3 + O_2 \rightarrow ZnO + 2\ CO_2$ $ZnO + \mathbf{H_2} \rightarrow Zn + \mathbf{H_2O}$
Cadmium Carbonate	$CdCO_3 + O_2 \rightarrow CdO + 2\ CO_2$ $CdO + \mathbf{H_2} \rightarrow Cd + \mathbf{H_2O}$
Cobalt Carbonate	$CoCO_3 + O_2 \rightarrow CoO + 2\ CO_2$ $CoO + \mathbf{H_2} \rightarrow Co + \mathbf{H_2O}$
Nickel Carbonate	$NiCO_3 + O_2 \rightarrow NiO + 2\ CO_2$ $NiO + \mathbf{H_2} \rightarrow Ni + \mathbf{H_2O}$
Rhodochrosite	$MnCO_3 + O_2 \rightarrow MnO + 2\ CO_2$ $MnO + \mathbf{H_2} \rightarrow Mn + \mathbf{H_2O}$
Witherite	$BaCO_3 + O_2 \rightarrow BaO + 2\ CO_2$ $BaO + \mathbf{H_2} \rightarrow Ba + \mathbf{H_2O}$
Strontianite	$SrCO_3 + O_2 \rightarrow SrO + 2\ CO_2$ $SrO + \mathbf{H_2} \rightarrow Sr + \mathbf{H_2O}$
Cerrusite	$PbCO_3 + O_2 \rightarrow PbO + 2\ CO_2$

$$PbO + \mathbf{H_2} \rightarrow Pb + \mathbf{H_2O}$$

Lithium hydroxide filters/canisters (made by combining Lithium oxide with water resulting in the product, Lithium Hydroxide monohydrate) can be used to adsorb CO_2, and is an effective means of CO_2 removal. The Lithium Carbonate waste can be recycled, that is, thermally regenerated by gently heating it to drive off the CO_2, leaving behind Lithium Oxide. During flame tests, Lithium colors a flame bright crimson. The reactions which take place are:

$$LiOH(s) + H_2O \rightarrow 2\ LiOH.H_2O(s)$$
$$2\ LiOH.H_2O(s) + CO_2 \rightarrow Li_2CO_3(s) + 3\ H_2O(g).$$

The gaseous water is from an astronaut's breath, the net reaction is that two moles of water are liberated for each mole of CO_2 chemisorbed.

A composite mix of Silver Oxide (Ag_2O) and Zinc Oxide (Zn_2O) can also be used to filter carbon dioxide.

Note: Mineral Rock Books are an indispensible aid when looking for different classes of minerals such as metal oxides, as they contain **color photos** and chemical formulas. We highly recommend: "Mineral Rocks" by Chris Pellant, DK Publishing, NY, NY. ISBN: 1-56458-061x. The book is organized by classes of mineral rocks such as the sulfates, carbonates, oxides and igneous and metamorphic rocks.

Reduction of Converted Sulfides

Sulfides can also be reduced with hydrogen, in a 2-step process: The Sulfides should first be "roasted" in an oxygen or oxidizing atmosphere, to form oxides; they can then be reduced with Hydrogen gas to produce *water* and free metal:

Copper Sulfide: $CuS + O \rightarrow CuO + S$ (Intermediate Step)
$CuO + H \rightarrow Cu + \mathbf{H_2O}$

Mercuric Sulfide: $HgS + O \rightarrow HgO + S$
$HgO + H \rightarrow Hg + \mathbf{H_2O}$

Cadmium Sulfide: $CdS + O \rightarrow CdO + S$
$CdO + H \rightarrow Cd + \mathbf{H_2O}$

Silver Sulfide: $Ag_2S + O \rightarrow Ag_2O + S$
$Ag_2O + H \rightarrow 2\ Ag + \mathbf{H_2O}$

Cobaltite: $CoAsS + O \rightarrow CoAsO + S$
$CoAsO + H \rightarrow Co + As + \mathbf{H_2O}$

Stibnite: $Sb_2S_3 + O \rightarrow Sb_2O + S_3$
$Sb_2O + H \rightarrow Sb_2 + \mathbf{H_2O}$

Molybdenite: $MoS_2 + O \rightarrow MoO + S$
$MoO + H \rightarrow Mo + \mathbf{H_2O}$

Bismuthinite: $Bi_2S_3 + O \rightarrow Bi_2O + S$
$Bi_2O + H \rightarrow Bi_2 + \mathbf{H_2O}$

Reduction of Mineral Rocks with *chemical* hydrogen produces water which is suitable for personal cleansing, washing, gardening, even in shellfish acquariums. Filtration with polymer materials or sand can also be used when deemed necessary. Depending on the intended use--water for drinking versus water for washing or farming--if there is any fear of using chemical hydrogen, then synthetic or natural citric acid (organic hydrogen) can be substituted, whenever Hydrogen is called for.

CONDENSATION TECHNIQUES

Since water vapor and CO_2 are byproducts of all hydrocarbon combustion, we can capitalize on recovering the water by condensing the vapors into water droplets. All water vapor produced from propane, butane and methane combustion is recoverable, the higher the octane, the more water produced. The colder it is, the faster it condenses. Through the use of freon-cooled glass panes, freon-cooled exhaust fans, chemical coolants, or refrigeration cooling coils the water is captured in containers; lab experiments have shown that water vapor has an affinity for cooled silicon glass.

On earth, all cooking appliances should be electric and even solar. Whereas on the Moon, they ***must be gas based*****, such as propane gas grills and ranges, methane gas stoves, tandoori gas ovens, etc.,** In one schematic, four tabletop burners are placed in a rectangular arrangement, and an exhaust fan with an aluminum duct wrapped with a flexible tube filled with a coolant, is placed 3 feet above the tabletop burners. Each propane gas burner is turned on a low flame. The exhaust fan draws the water vapor up the duct, which is cold, and condenses the vapors to water droplets, and a container is placed under the aluminum duct to collect it. Please note that at least one aluminum duct and exhaust fan should be set aside and used solely for making water to prevent cooking oils from tainting the water, for this very reason, scheduling is critical. For example, the burners should be scheduled to be on between 3 pm - 5 pm only, and then again from 11 pm to 4 am, that is, during non-cooking hours.

Another simple and effective alternative is to use air conditioners or dehumidifiers to condense the water vapor into droplets, think of these devices as clouds. In this schematic, 4 stoves (ovens intact) are strategically placed in a large kitchen; while baking, the oven doors must be closed, but the broiler doors should be left open to allow the flames to combine with the oxygen in the kitchen/room to form water vapor and CO_2. *The air conditioners or dehumidifiers would draw the water vapor in and condense it into droplets, which can then be collected in a container. Measure and cut off 3 feet of plastic tubing, connect it to the hole on the bottom of the air conditioner where the excess water drips out; place a water jug or plastic container to collect the water droplets. Dehumidifiers generally come with built in receptacles which collect the water. Again, while baking, close the oven doors, but leave the broiler doors open and make sure there is plenty of oxygen available in the kitchen/room by hanging plenty of plants on the ceiling. Roasting and simmering soup is also especially well suited for making water vapor since these slow cooking processes burn a signficant amount of methane or propane over time.*

Organic methane gas for cooking is made by fermenting biomass with freshly cut *green grass* in a container, this has been done for centuries in Asia. Grass can be grown in containers mounted on towering structures with shelving, for example, a columnar rack system with shelves to hold the containers of grass. Ivy and other climbing/hanging plants can be hung from ceilings, from wooden ceiling racks, from flowering rotundas, grown on poles and support beams, etc. to provide adequate Oxygen. Evergreens and bush-type foliage are sturdiest. The CO_2 given off during the combustion and respiratory processes serves as one of the inputs to the photosynthesis process, producing more oxygen, hence, a vital ecosystem is formed. Any form of biomass (shrimp shells, orange peels) which have been dried, either naturally or in an oven, can later be burned in a partially covered container to produce CO.

Lithium hydroxide filters/canisters (made by combining Lithium oxide with water) can be used to adsorb CO_2. These are used on the Space Shuttle today. The reactions which take place are:

$$LiOH(s) + H_2O \rightarrow 2\ LiOH.H_2O(s)$$
$$2\ LiOH.H_2O(s) + CO_2 \rightarrow Li_2CO_3(s) + 3\ H_2O(g).$$

The gaseous water is from an astronaut's breath, the net reaction is that two moles of water are liberated for each mole of CO_2 chemisorbed.

During combustion, the higher the octane fuel used, the more water vapor is produced. Water vapor from fuels synthesized by the Fischer-Tropsch process does not contain contaminants, like sulphur dioxide, lead or other known exhaust chemicals from petroleum (fossil based) products.

In still another configuration, a glass "roof" is the condensing mechanism that is placed over a propane burner. Two glass panes encase a coolant which causes the water vapor to condense on contact with the cold glass and drip into a collector. Please refer to Exhibit A.

As stated, Air Conditioners are a simple and effective means of condensing water vapor to droplets. Measure and cutoff 3 feet of plastic tubing and connect it to the opening on the bottom of the air conditioner. Place a bottle under the tubing to collect the water droplets. The higher the BTU, or the colder it is, the faster the water condenses.

Dehumidifiers, which work by removing moisture from the air, can also be used. Different models remove different rates of water, generally in pints/hour.

Burning Paraffinic products ($C_{21}H_{44}$) such as wax candles also yields water, CO_2, and pure carbon. The yield would be 22 moles of water for every mole of paraffin burned in the presence of 32 moles of oxygen:

$$C_{21}H_{44} + 32\ O_2 \rightarrow 21\ CO_2 + \mathbf{22\ H_2O}$$

Plant Transpiration accounts for approximately 10% of all evaporating water. Transpiration is the evaporation of water into the atmosphere from the leaves and stems of plants. Plants absorb soilwater through their roots and this water can originate from deep in the soil. (For example, corn plants have roots that are 2.5 meters deep, while some desert plants have roots that extend 20 meters into the ground). Plants pump the water up from the soil to deliver nutrients to their leaves. This pumping is driven by the evaporation of water through small pores called "stomates", which are found on the undersides of leaves.

FUEL CELLS

Fuel Cells have been used to provide *water* and power to the Mir Space Station since the 1960's and more recently, 90 power plants have been installed for the Apollo Command and Service Module spacecraft; as well as 25 power plants for the Space Shuttle Orbiter spacecraft. There are many fuel cell designs in existence today, but the basic operating principles are similar and simple in concept. Take carbonate fuel cells as an example, the reactants — fuel and air (the oxidant) — are fed to the cell's electrodes. Ions are transported through the electrolyte sandwiched between the electrodes, creating a current equal to the externally connected load. The basic reactions are:

Overall:
Natural Gas + Air → **H_2O** + CO_2 + Electricity + Heat

Reforming Reactions:
Natural Gas + Steam (water + heat) → Hydrogen + Carbon Monoxide

Anode Reaction:
Hydrogen + Carbon Monoxide + Carbonate Ion → **H_2O** + CO_2 + Heat + Electricity

Cathode Reaction:
CO_2 + Oxygen + Electrons → Carbonate Ion

While natural gas is the primary fuel, with appropriate cleanup any hydrogen-rich gas — including gas from landfills, digesters, coal mines, or liquid fuels — can be supplied to the fuel cell. Note that electricity, heat, water vapor, and carbon dioxide are the products of these basic reactions. It is a known fact that *Hydrogen* is one of the most abundant gases in the Universe, fueling the sun's fusion processes and expelling helium gas. Hydrogen is estimated to make up more than 90% of all the atoms or three quarters of the mass of the universe.[1]

Electrical power for NASA's Space Shuttle Orbiter is provided by fuel cell power plants designed, developed, and built by International Fuel Cells. In the Orbiter, a complement of three 12kW fuel cells produces all onboard electrical power; there are no backup batteries, and a single fuel cell is sufficient to insure safe vehicle return. *The water produced by the electrochemical reaction is potable water, of drinking quality, used for crew drinking and spacecraft cooling.* Each fuel cell is a self-contained unit 14 x 15 x 45 inches, weighing 260 pounds. Each is installed under the payload bay, just aft of the crew compartment and is fueled by hydrogen and oxygen from the cryogenic tanks located nearby. Each fuel cell is capable of providing 12kW continuously, and up to 16 kW for short periods.[2] Each power plant contains 96 individual cells of alkaline (KOH) electrolyte technology which are connected to achieve a 28 volt output. At 200° F, 4 atm operating conditions, the cells are over 70% efficient (a typical combustion engine is only about 25% efficient); this high efficiency and light weight led NASA to select fuel cells to power the Space

Shuttle Orbiter.

WATER TREATMENT

Chlorination, Distillation, sand pumps and Activated Carbon filters are all good aseptic filtration methods. The most effective for drinking water is Ozone treatment prior to bottling. There are several vendors on the website offering these products. Corona-generated Ozone Purification machines are considered to be the best and most effective water treatment technology. The primary effects of ozonation of drinking water are:

a) Bacterial disinfection and viral inactivation.
b) Oxidation of inorganics such as iron, manganese, heavy metals, cyanides, sulfides and nitrates.
c) Oxidation of organics such as pesticides, herbicides, phenols, taste and odor caused by impurities.

Ozone, referred to as Triatomic oxygen, is an unstable gas having life in water of minutes. Oxygen, which is normally bi-atomic, becomes ozone through the addition of a third unstable atom. Ozone, because of its instability must be generated and used for treatment immediately. It is created by one of two generation methods: Ultraviolet radiation or corona discharge. Of the two, corona discharge produces the substantially higher ozone concentration needed for the removal of complex impurities. Generated ozone is pumped into the water through a stone of fine porosity, creating very small bubbles which rise slowly through the water. Most critically, ozonation does not add chemicals to the water as does chlorine, chlorine dioxide, permanganate, etc. As the ozone passes through the water, the third unstable atom detaches, attacks, and destroys impurities in the water. The residue in the water is pure oxygen, which quickly dissipates in a few minutes. Any excess ozone which is not needed for treatment, reverts to simple oxygen in 20-30 minutes.[5]

Bacterial disinfection and viral inactivation:

E-Coli bacteria are destroyed by ozone concentrations of just over 0.1 mg/liter and contact time of 15 seconds between 77^o - 86^o F. Streptococcus fecalis are much more easily destroyed using ozone concentrations of .025 mg/liter, and 99.99% inactivation is obtained in 20 seconds or less.

Oxidation of inorganics:

Iron, manganese and several arsenite/arsenate compounds are oxidized rapidly, leaving insoluble compounds which are easily removed through filtration using an activated carbon filter. Nitrite ions are oxidized to nitrate ions which are stable and innocuous. Sulfide ions are oxidized sequentially to sulfate ions, also an innocuous substance.

Oxidation of organics:

Ozone is very effective in treating organic materials. Some organics react with ozone very rapidly to destruction, within minutes or even seconds, whereas others react more slowly. In some cases, organic materials are only partially oxidized with ozone, in which case, the complex insolubles are removed by activated carbon filters.

Protection from the Elements

When temperatures vary greatly, as when the Moon is eclipsed from the Sun for several hours and then exposed to the Sun again, temperatures will swing sharply. Structures have to be built with fans which circulate hot and cold air to provide an ambient temperature; this would be accomplished by building a tall, hollow ceiling or roof with fans hanging from the ceiling, in which hot and cold air would mix before it is channeled to other quarters. Solar Array panels should be set up during the day to store solar power in batteries and inverters can be used to change low voltage DC power to high voltage AC power. A generator would provide backup AC power. At night, a vast series of heaters, set at the maximum thermostatic control, can be hooked up to solar batteries to provide heat and hot water.

Lead (Pb) tiles should be sandwiched between layers of building materials to prevent radiation from coming through. For example, if the exterior is a wall of bricks and the interior is a wall of concrete or wood, the Lead tiles should be placed between them. One may also build refractory glass to reflect the sunshine out to space.

Carbon dioxide (pressurized) can be made into dry ice by leaving it out at night to freeze. During the day when it is hot, the dry ice blocks can be used to cool the living area; in a warm environment, the dry ice would sublimate directly into gaseous CO_2, providing plants with a greenhouse environment.

Another alternative is to live underground, as in an underground city. Robotic devices can be outfitted with jackhammers to drill holes and explosives can be used to excavate structures. Although Mars appears daunting, earthlings can be protected by building living quarters in Mount Olympus, the largest inactive volcano in the solar system.

Water is also very effective at absorbing ultraviolet light, therefore, glass beams/walls filled with water can be built for protection. Solar Panels with inverters can be used to store energy for use at night, when energy is needed to fuel heaters to provide warmth.

Laptop PC's loaded with how-to information should be on board each expedition, and telecommunications equipment set up to test communications with Earth should be established, i.e.,providing e-mail and video conferencing capability with inhabitants of the Moon and Mars to provide technical and moral support.

HIGH TECH ANIMAL HUSBANDRY

Xybex is a pioneer in the research and use of surrogate animals to produce cows, pigs, goats and deer through high tech animal husbandry/farming methods. Artificial Insemination is a widely practiced technique used by breeders to produce superior breeds or enhance the chances of successful breeding of problematic herds; in-vitro fertilization and embryo transfer is rapidly becoming a mature technology. The number of potential ova in the ovaries of a heifer exceeds 75,000 when she is born. After maturation any number of these ova could be harvested for in-vitro fertilization.

Our research effort focuses on using *one* surrogate mammal, for example, heifers or cows, to serve as surrogates during the gestational period for different embryonic species. By transporting frozen embryos to other planets and implanting them on arrival, it may be possible to breed successive generations from just *one* female animal, for example, the cow. It is far more efficient to transport frozen embryos on a space journey and ***one*** cow, (or one female of each species and the cryogenically frozen sperm of each species) than to bring pairs of each animal.

Xybex does not advocate use of liquid nitrogen as the cryogenic freezing medium during long-haul space travel since much research has revealed that liquid nitrogen has damaged embryos and spermatozoa beyond recovery.[6] It is suspected that liquid nitrogen, being a super-cooled liquid, is much too cold. Frozen CO_2, or chipped Dry Ice, is a safer storage and delivery medium. A solution of 0.4% Modified Buffered Saline, 0.1M Sucrose and 10% Glycerol is still the preferred liquid medium for submersion and cryogenic preservation.

Approach:

Dairy goat embryos will be cultered using media supplemented with gonadotropins and co-culturing with oviductal and granulosa cells. Dairy goats will undergo laparoscopic methods of recovering pronuclear stage and cleaving in-vivo, fertilized oocytes.[7] Successfully formed, healthy embryos will be cryopreserved with 1.4M glycerol or vitrified using a 2M glycerol extender, for later transfer into heifers or cows for the remainder of the gestational period, in this case 9 months.

Chicken Breeding

By bringing baby chicks and using fertilized eggs and incubators, chicken farms can be started. The technique for producing eggs en masse is to trick the hen into thinking it's daylight, this is accomplished by turning the lights on at different 15 hour shifts, and off for 15 hours. For good quality eggs with hard shells, it normally takes 24 to 28 hours for the egg to form inside the hen. 15 hours results in eggs with thinner shells, but a greater quantity of eggs are produced. Chickens lay about 320 eggs a year.

Chickens are often fed a special "hen-lay formula" to optimize yield. One organic formula consists of: Cracked Corn 58 %, Soymeal 30 %, Oyster

shell 5 %, Lime 4 %, Layer minerals
3 %.

The base is comprised of wheat, with proteins coming from flax, canola or sunflowers meals, by-products of oil processing. Sesame, soy and borage meals are also included along with flax, canola, soy or borage oils. Vitamins are added as a pre-mix along with lysine, thiamin, salt, limestone and phosphate rock.

Another producer uses this formula:

Five to six times each day, the hens are fed automatically. The main ingredients in their certified organic feed are corn, barley, rye, roasted soys, wheat and oats. Hulless oats are excellent because of their near-ideal protein/energy balance. The vitamin/mineral premix is specially formulated using limestone, calphos, synthetic vitamins and amino acids.

There are two main breeds of Layers: White Leghorns, which produce white-shelled eggs and Rhode Island Reds, which produce brown-shelled eggs. A typical pullet hen, an "adolescent" hen of either variety, starts laying eggs at about 18 weeks of age and continues to lay the highest quality eggs for the next 13 weeks, until it's 31 weeks old. The hen is considered "adult" when it reaches the age of 31 weeks and continues to lay eggs for an additional 69 weeks until its reaches the age of 100- 102 weeks. A fertilized egg from a chicken takes 21 days to hatch. Chicks have to stay very warm until they grow regular feathers. The first week they need 95 degrees, the second week 90 degrees and the third week 85 degrees.

The hen is considered "over-the-hill" in terms of its egg-laying life when its about 2 years old. By then, the frequency of laying and quality is so low that it's time to ship the hen off to the meat market.

REFERENCES

Richardson, James T., *Principles of Catalyst Development*. 1989, Plenum Publishing Corporation, New York. ISBN Number: 0-306-43162-9.

Brady, James E., Chemistry: *The Study of Matter and Its Changes*. 1993, Published by John Wiley and Sons, Inc. ISBN Number: 0-471-53008-5.

Hill, John William, *Chemistry For Changing Times*. 1988, Macmillan Publishing Company.
ISBN Number: 0-02-355010-4.

Equity Research Report, *Fischer-Tropsch Technology*, 1998, published by Howard, Weil, Labouisse, Friedrichs, Inc., Houston, Texas.

"*Mineral Rocks*" by Chris Pellant. 1995, DK Publishing, New York, NY.
ISBN Number: 1-56458-061-X.

Dorin, Henry, *Chemistry – The Study of Matter*. 1987, Published by Allyn and Bacon, Inc. ISBN Number: 0-205-09620-4.

FOOTNOTES

[1]Note: Brady, James E., Chemistry: *The Study of Matter and Its Changes*. 1993, Published by John Wiley and Sons, Inc. ISBN Number: 0-471-53008-5.

[2]Note: International Fuel Cells, LLC, a subsidiary of United Technologies Corporation, is located in South Windsor, Connecticut, U.S.A. Their website is: http://www.internationalfuelcells.com.

[3]Note: The Activated Metals & Chemicals Group, part of the Celanese Hoescht Corporation is a catalyst manufacturer, an ounce of Cobalt Catalyst costs about $400, their website is: http://www.amcpmc.com.

[4]Note: *Technology Transfer of Citric Acid Production process:*
Contact: Yuan Jian xin
No. 287 Heping Road, Heping District, Tianjin, China. Post: 300041
Tel: (022) 27126410 Fax: (022) 27123812

[5]Note: Hess Machine International, "*How Ozone Works*", 1999.
Website: http://www.hessmachine.com Tel: 800.735.HESS or 717.733.0005

[6]Note: NC State University, College of Agriculture and Life Sciences.

[7]Note: Samake, S., E.A. Amoah, S. Mobini, O. Gazal and S. Gelaye. 1997. *In Vitro Fertilization in the Goat*. Proc. 11th Biennial Symposium Association of Research Directors. San Antonio, TX. October 1-4, Agricultural Research Station; College of Agriculture, Home Economics, and Allied Programs; Fort Valley State University; P. O. Box 5744; Fort Valley, Georgia 31030; (912) 825-6322. Website: http://www.ag.fvsu.edu.

Chicken Farming

[8]Note: http://www.saturdaymarket.com/eggs1.html
http://www.mbegg.mb.ca/farm.html

Animal Husbandry-related Websites:

http://www.inform.umd.edu/EdRes/Topic/AgrEnv/ndd/reproduc/
http://www.cals.ncsu.edu/an_sci/extension.old/animal/ahbeef.html
http://www.ag.fvsu.edu/html/research/projects/projects.html

Sugarcane Sales

AG-RAY Land & Sugar Plantation
1 ½ E 3 Miles N
Mercedes, Texas
Tel: (956) 565-3327

NRF Cane Planting Corporation
408 W. Jonquil Avenue
McCallen, TX 78501-1827
Tel: (956) 687-3737

Sugarbeet Sales

Seedex, Inc.
1350 Kansas Avenue
Longmont, CO 80501
Tel: 1-800-777-7272
Fax: 1-303-678-7337
e-mail: (dyearous@seedexseed.com)

Sugarcane milling equipment
http://www.fultoniron.com/juice-extraction.html

Cattle Companies
Wentz Cattle Company
1 Mile SW of Post
Olmito, TX 78575
Tel: (956) 350-4445

Condensation Coils
Shur-Kut Corporation
Designs and engineers coils for all applications.
Website: http://www.shurkutcoil.com

Beverage/Water Dispensers
http://www.stcplastics.com

Fruit Seeds/Vegetable Seeds/Plants/Grass
http://www.burpee.com

Enzymes – Dextrose/Fructose Production
Enzyme Development Corporation
2 Penn Plaza, Suite 2439
New York, NY 10121
Tel: 212.736.1580 Fax: 212.279.0056
e-mail: info@EnzymeDevelopment.com
http://www.enzymedevelopment.com/starch.html

Lithium Hydroxide suppliers
(Ask for Lithium oxide and mix with water to form a metal hydroxide.)
http://www.stanfordmaterials.com

Fresnel Lenses
Special lenses which focus light rays into intense heat waves.
http://www.edmundscientific.com

Pulverizers

(Used to grind or "pulverize" ores, minerals and other substances into a fine powder)
Coffee Bean Grinders are very effective at grinding eggshells into powder.

http://www.plastomerproducts.com
Air Pulverizers require a Compressor.

http://www.bicoinc.com
Model 242-641 is sufficient to grind clam shells.
(818) 842-7170

Ethanol Production from Grain
http://aceis.agr.ca/research/cfar/coprod.html

Live Seaweed
(Use to make oxygen backpacks by adding a wet sponge; and a red, blue or violet light bulb and batteries. Note: your respiratory membranes are *specialized* to absorb oxygen, and your lungs remove excess water formed from respiration, expelling it as gaseous vapor, sweat or urine.)
http://www.alcasoft.com/seaweed/howorder.html

Custom fabricated Space Suits
No oxygen tank is provided, although a fan draws the air into the suit.
http://www.spacesuit.net

Acetone-butanol fermentation performed by the bacterium *Clostridium acetobutylicum*.
Presque Isle Cultures, Inc. Bacterium # 657.
http://www.picultures.com

Solar Energy Arrays – Stored Solar Energy Panels
Sunelco
100 Skeels St., P.O. Box 787, Hamilton, Montana 59840-0787.
(800) 338-6844 to order (406) 363-6924 for more information.

International Seed Bank (planned); grafting fruit trees; propagating root vegetables.
http://www.makewater.net

SASOL Synthetic Gasoline Refinery
http://www.sasol.com

Syntroleum

http://www.syntroleum.com

Rentech, Inc.
http://www.rentechinc.com

Fischer-Tropsch Site
http://www.fischer-tropsch.com

Dresser Engineering
Process Plant Engineering
http://www.dressereng.com

Bateman Engineering
Process Plant Engineering

Haldor Topsoe
Process Plant Engineering

Hitachi Zosen
FT Reactor Fabrication

U.S. Space Alliance
http://www.unitedspacealliance.com

Bioprocess Technology
An encyclopedia on Fermentation, Biocatalysis & Bioseparation Technology – Citric Acid production.
ISBN No. 0-471-13822-3, a Wiley Publication.
http://www.blackwell.com

International Fuel Cells, LLC.
Builds and installs Fuel Cells for the Space Shuttle Program.
http://www.internationalfuelcells.com

The Activated Metals & Chemicals Group
Part of the Celanese Hoescht Corporation, specializing in catalyst manufacturing, an ounce of Cobalt Catalyst costs about $400. Price decreases as tonnage increases.
http://www.amcpmc.com

Raytheon Engineers and Constructors
http://www.raytheon.com
Design, construction and validation of citric acid and alcohol plants.

Westfalia Separator, Inc.
Design and implementation of fermentation processes and technologies to produce yeasts, alcohol, amino acids and citric acid.
http://www.westfaliaseparatorus.com

Compost Tumbler
Composter to make soil from restaurant, farm and kitchen waste.
1-800-880-2345

Oceanariums
Lobster tanks complete with 6 stages of filtration, heavy oxygenation via oxygen reactor and wet/dry filter; insulated and waterproof.
www.oceanariums.com

AquaCare Corporation
Fish farming tanks made of Permaglas for intensive fish farming, fresh or saltwater; roofs and covers available; round fish rearing tanks.
www.aquacare.com

Conversion of Biomass/Waste to Methane Gas

Exhibit A

Exhibit B

1. Quickly blanch 1 dozen eggshells by dropping them into boiling water for 2 minutes, drain; place eggshells in a paper bag and smash into bits with a rolling pin, then pour into electric coffee bean grinder to pulse into powder. A Pulverizer can also be used.
2. Blend 4 cups of fresh fruit and pour into a 2 or 5 gallon dispenser. Add 1/3 cup of citric acid and 1 cup of sugarcane or sugarbeet juice; stir; wrap ½ cup of powdered eggshells loosely in a square of cheesecloth, tie with string, drop in dispenser, and cover tightly.
3. Allow to stand for 3 hours at room temperature, or 50 degrees F; when fizzing stops, add 2 gallons of fruit juice, or sugarcane/beet juice, or water and shake dispenser well.
4. When ready to serve, sweeten to taste by spooning 3-4 tablespoons of cane or beet sugar into a tall glass, dispense by filling to the top of the glass, stirring well. Remove and discard eggshells after 3 hours by lifting cheesecloth and discarding contents (the calcium citrate precipitate).

Remember: Water and CO_2 are given off by the reaction of citric acid and carbonate shells, and your body metabolizes the sugar producing water and CO_2. So drink up! Just remember to relieve yourself at the nearest sugarcane, vegetable field, or fruit tree.

Note: Clams should be gently steamed to open them and the shells must be pulverized into a fine powder using a Pulverizer.

SUGGESTED RESTAURANT MENU
This special menu consists of entrees made with eggs and seafood/shellfish.

BREAKFAST
Omelettes
Ham, Sausage or Bacon
Eggs – Scrambled, Over Easy, Hardboiled, Eggs Benedict
Waffles & Whipped Cream
Boysenberry Pancakes

LUNCH
Astronomical Quiche – Ham, Cheese, Prosciutto & Broccoli Quiche
Scintillating Crepes – Cream of Chicken, with Gruyere Cheese, fresh cream & Prosciutto Ham
Lobster Nebulae – with fermented black soy beans, garlic, scallions, pork & eggs
Lunar Crescents - Turnip, Scallions, Pork, Shrimp & Egg Crescent omelettes
Eggs Callisto – Duck eggs preserved in a special broth served with a Baked Vegetable Souffle
Uranian Platter - Egg Salad arranged with Fresh Greens, Capers and Oyster Mushrooms

DINNER
Salad & Herb Dressing
Plutonian Pate – Gooseliver sauteed in shallots, wine, capers, mushrooms and Papaya slivers
Clams Andromedus
Sizzling Conch with Stellar Shrimp Sauce
Venusian Escargots with Oyster Sauce, Scallions, Ginger & Garlic
La Isla – Souffleed & Steamed Eggs with Oyster Sauce & Sizzling Soybean oil
Razor Clams Ganymede

DESSERT
Orbital Ice Cream – in out of this world flavors: Blueberry Europa, Cherry Io, etc.
Raspberry Cheesecake Moons
Powdered Orbiting Cream Puffs
Floating Napoleans
Milky Way Eclairs

Lemon Meringue Pie