REFRIGERATION and alternatives for Alternate Energy People.

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Humans originally were hunter gathers. The acquisition of food and water were essential, and probably consumed much of their time. Food was found to last longer when cooked, and smoking the food for preservation was probably discovered shortly after that. "Sun drying" was also discovered a long time ago, as with "salting". Later, farming provided a continuous source of food, with animals being farmed as well. Things changed a bit when "trade" was more common place however , because people liked to have "fresh produce". "Storage pits", "barrel pits";, "storage cellars" , "bottling" , "pickling", "salting", "smoking" , "drying" etc , didn't provide this so a better way to hold foods freshness was sought. Cooling was known to work since the year dot, but sufficient "cold" in a warm country was a problem. Ice was harvested for a while with many people using ice chests, some even had "crosley icyballs" , which was an intermittent absorption refrigerating device. In 1834 , an American resident in England, Jacob Perkins, built the first practical vapor compression machine. This has essentially the same "parts" as the modern refrigerator. Different refrigerants have been tried, Ammonia, sulfuric ether, carbon dioxide, methyl-chloride, some hydro-carbons and some halocarbons known as "freon", "genetron" , "Isotron" etc.

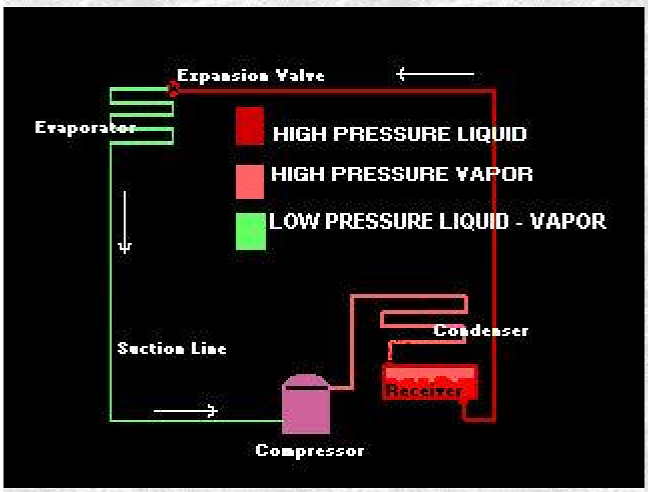
Up to this point, people managed to do without refrigerators because they farmed, preserved food, had milk on tap etc. { A short human history is below}. Modern commerce has made refrigeration a necessity, with cold rooms at the farm, refrigerated container storage for shipping, road, air and rail, and then again at the markets and stores, and then finally to your fridge. . . . But what it really boils down too is lifestyle. Most of us like the convenience of being able to grab the milk etc, and make a cup of coffee, or have some choice for dinner or tea. The reality is, if your a city or suburban dweller, your refrigeration needs could be substancially minimized by using your "local" stores fridges. That is, get the meat for dinner on the way home from work, etc, or when you need it. This way the stores have to display their best stuff or you don't come back, and you won't get caught buying a bulk order of "poor quality" meat etc. Vegetables are also a game of Russian roulette, not keeping long after industrial cold storage, so it really makes sense to regularly buy small quantities of fresh food. Some people have already changed their lifestyles and given up on buying and "storing" fresh produce, and now buy "take-away" every day. These people probably have very little need for a fridge, and possibly could get by with a very small refrigerator. (if it wasn't for the beer . . . . . .)
Unfortunately for rural people, a walk to the shops is unthinkable, so large freezers and fridges are a fact of the modern life. However a lifestyle change could minimize the refrigeration requirements for anybody willing to try. There are many ways to do this and solutions can be found by borrowing from practices from the past. . . , , (Also via solar energy),

Lifestyle change - 1st step, - other possibilities might be,

Solar trough absorption system.
A homebrew crosley iceball in conjunction with an icechest.
Good thermally insulated icechests, or , ultra efficient fridge running off solar energy (see "shopping for a fridge, below).
Traditional food preservation techniques - use of cellars etc..
Grow a variety of fruit and crops which provide food for all year round (pick the things that were successful to "your" area in the past).
Consider keeping animals that provide a mutually beneficial partnership, like chooks, goats, cows, etc.

So what does refrigeration do, and how does it work? -

Refrigeration is required to slow the activity of bacteria which will spoil foods. Bacteria will grow rapidly in temperatures of 4.5 deg C to 60 deg C. (40 -140 deg F). Freezing will stop almost all bacterial activity, so foods can last a long time. Most foods taste and appearance are not affected by refrigeration (however - fruit and some vegetables can become soft and disgusting) and will remain "fresh" for perhaps 1 to 2 weeks instead of 1 or 2 days. The fridge should be maintained at 3 deg C (38 deg F) and the freezer at - 17.5 deg C (0 deg F) or better.
Milk will spoil in as little as 12. 5 minutes with "Escherichia coli" bacteria in a 37 deg C (98.6 deg F) heat, and there are many other varieties of bacteria growing as well! . Because the aim of food preservation is to reduce the production of bacteria, good hygiene, in the handling of food should be very important.
Food should be stored in the fridge in shallow containers soon after cooking to promote rapid cooling.
Using the freezer to "snap cool" is an idea worth trying, and then transfer to the fridge section later .
"Left overs" because of the possibly high bacterial contamination should be re-heated to kill any bacteria and eaten or disposed of as soon as possible. Below is some do's and dont's for refrigerators and some guides to keeping safer food

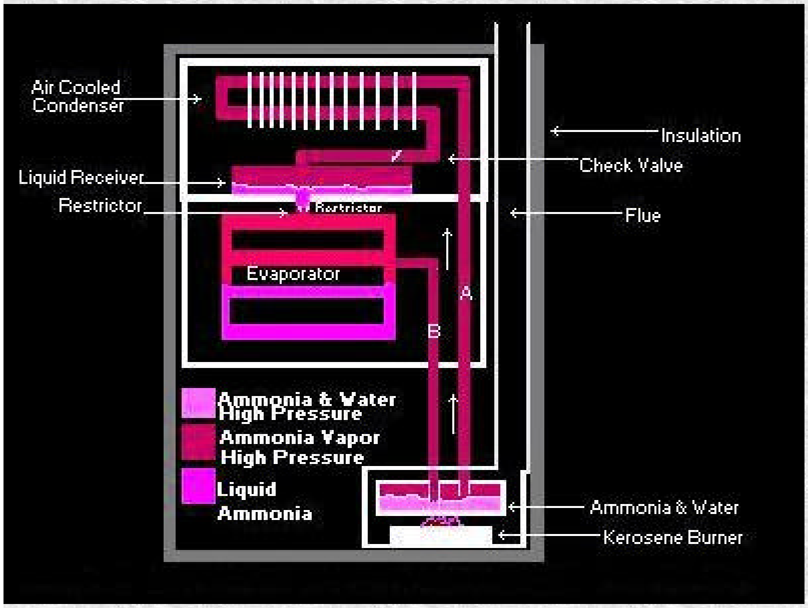


Refrigerators or air conditioners etc, consists of an evaporator coil , which may include an expansion valve, a compressor, a condenser coil and some refrigerant. When the liquid refrigerant is in the evaporating coil it has the opportunity to absorb heat and boil off as a gas. This is assisted by the compressor which creates a suction head in this part of the system, which lowers the boiling point of the refrigerant. The compressor recovers the gas and pressurizes the returned refrigerant vapor which condenses back to a liquid giving off heat in the condenser coils. From there it flows to the evaporator coil to recommence the cycle again.
A modern "frost" free refrigerator is one that has heating elements incorporated at the frost points (ie around door seals, evaporator coil etc) so no build up of ice is possible. The heaters are timed on and off and also by a temperature sensor which monitors the freezer cabinet temperature. This is done so no food is actually defrosted while de-icing, but this process does fluctuate the food temperature up and down. The heaters also consume a fair bit of energy , so this type of fridge would be best forgotten by alternate energy people. If you are on mains supply however, still buy a fridge with the best energy rating you can. (there are some frost free's better than standard ones about now ! - running costs of 480 kWhr / yr or 1315 Whr / day for a 360 litre)

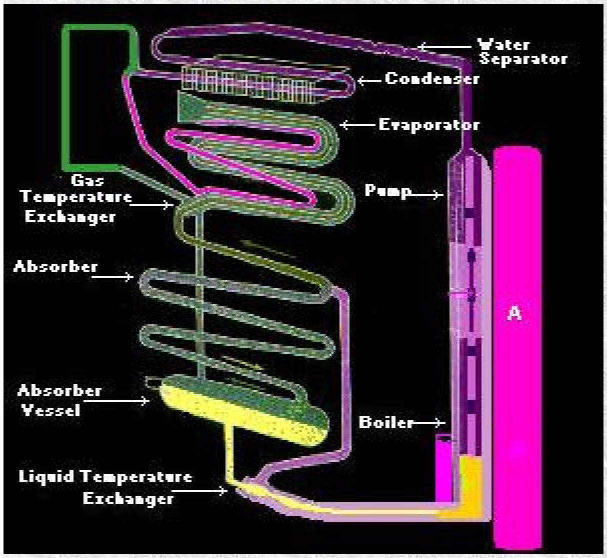
More depth:- To understand the role of the refrigerant an understanding of it's properties and some physics is required. When the refrigerant gas is compressed it's volume is reduced which raises the pressure and temperature of the gas. If the pressure was further increased or the gas temperature reduced it would generally liquidize. This is the function of the condenser coils, to remove heat and allow the refrigerant to condense and liquefy. This heat is known as the "heat of condensation" and is negatively equal to the "heat of vaporization" - so the heat coming from the back of the fridge "coils" is approximately the heat being removed from the interior of it. The liquid refrigerant then flows to the expansion valve and evaporator coils. The expansion valve (if incorporated) and evaporation coil provide a small orifice for the refrigerant to pass through. This allows the refrigerant to pass from a high pressure zone (compressor output) to a low pressure zone, (compressor inlet , or return, suction). This lets the refrigerant "expand" out into a gaseous state. The refrigerants physical properties allow it to boil (evaporate or flash) at some specific low temperature for a given pressure. (For example, Ammonia, NH_3 @ 1 atmosphere will boil at -28 deg F or -33.4 deg C, when the pressure is reduced to 10 inches of suction, ammonia "boils" at -40 deg F or -40 deg C, even colder , - however ammonia is rarely used in modern domestic situations as it is dangerous if it leaks). When this physical change from a liquid to a gas takes place (a phase change) energy is absorbed without any change in temperature. From the liquid state to a gas is known as the latent (hidden) heat of vaporization. For Ammonia it is 1369 kJ / kg (or 589.3 BTU / lb).

The evaporator coils serve to pull in surrounding heat which is absorbed by the refrigerant as it becomes a gas, and is made easier and colder by the compressors suction. In a refrigerator the evaporator coil surrounds the freezer section, with part of it supplying some absorption for the main section of the fridge.
In systems where heat loads may vary considerably a liquid receiver and a thermostatic expansion valve are incorporated. This valve (tx valve) regulates the flow of refrigerant to the evaporator by monitoring the evaporators outlet temperature. When the temperature there is above the refrigerants "boiling" point (or flash point @ that working pressure- see notes at bottom) then there is no possibility of liquid being returned to the compressor which would quickly destroy it. Also if the temperature gets high enough the valve opens to release more refrigerant to the evaporator to cater for the additional heat load increase. This margin temperature at the evaporators outlet is called "superheat". The liquid receiver is there as a reservoir to cater for the evaporators changing needs.

Air conditioning plants are basically refrigerators, but the heat load is circulating air from a room. The higher the differential temperature between the evaporator coils and the circulating air the higher the heat load to the system is . The air speed through the evaporator coils also dictates the heat load because the more air there is the greater it's capacity is to conduct heat away. So in choosing an air conditioning system the heat load should be known, that is the number of people working in the room, how much heat gain there is to the room from outside, and what differential temperature needs to be achieved. (inside - outside temp.)



Early domestic refrigerators were a mix of an electric compressor type, or an **intermittent absorption system** because many people were still living without electricity. This system is "temperature" driven instead of "pressure- compressor" driven , and it used a "generator" charged with ammonia and water. Energy was provided by a kerosine heat source which would heat the generator to supply enough "cold" until the next day. The fridge would need another fill of kero and re-lighting to kick the process over again the next day. On lighting, the generator would release ammonia vapor which would condense in the condenser coils. The liquid would flow by gravity to a liquid receiver. Until the kero had exhausted (20 - 40 minutes) the system pressure was too high for the liquid ammonia to vaporize and virtually no refrigeration took place. Once the system cooled down however, the system pressure became low enough for the ammonia to boil off and provide cooling in the evaporation coils, which was fed from the receiver. After that, with ammonia being highly attracted to water the gas is re-absorbed back to "aqua ammonia" solution in the generator ready for the next cycle.



Improvements were made to this system to make a **continuous absorption refrigerator**.The system is more complicated but still uses a heat source to drive it, such as kero, propane, engine manifolds, solar energy or electricity, and still has no moving parts. It differs from the intermittant system because there is no "cooling down" phase to reduce pressure to promote ammonia evaporation. This system uses ammonia, hydrogen and water with a system pressure at room temperature high enough to let the ammonia condense to a liquid. A boiler is heated with a "whatever" energy source, which causes ammonia gas bubbles to rise up from the boiler towards the conderser. This vapour is heavily laden with water vapour as well which is separated from the ammonia vapour before the condenser with a "water seperator". Heat of condensation is given off by these condensation coils into ambient air as the ammonia cools to liquid. The evaporator has hydrogen gas in it which passes over the liquid ammonia to lower it's vapor pressure enough for the ammonia to evaporate and provide cooling. The mixture of ammonia and hydrogen gas pass on to the absorber. The weak aqua ammonia solution and condensed water from the separation process to the condenser are also returned to the absorber to recombine with ammonia gas and back to the boiler for another cycle around. (Ammonia readily dissolves in water.) The hydrogen gas continuously circles around the evaporator and absorber circuit. The hydrogen gas replaces the expansion valve or "the cooling down phase " in this system to create a pressure differential for the liquid ammonia to evaporate. The total pressure of the confined system of gas is the sum of the pressures of each gas - "Dalton's law", and each gas behaves as if it occupies the space alone

Gas (etc) refrigerators never got off the ground when refrigerators were the "new" appliance to get because they were beaten by marketing. A bit like "beta" VCR's and good ol' DRDOS, and many other things. Absorbtion refrigerators are based on clever and sound principals, they run efficently and quietly and should be reliable for many many years. The absorption principal is making a come back however, in cooling devices to go with recreactional vehicles as it can utilise electric power and waste engine heat.

Another device widely used for this application is called a **"peltier junction" or "thermoelectric module"**. This is a "heat pump" which will which absorb heat from one side of the device and transfer it to the other when it is supplied with a dc current, and is ideal for small "coolers". It works on the principle that if a current is passed through the free ends of two dissimilar metals a temperature differential will result. The thermoelectric modules consist of a number of semiconductor blocks made of alloys of Bismuth and Tellurium which are electrically connected in a ceramic wafer sandwich. As current flows through the module it attempts to establish a new atomic equilibrium within the materials. The current treats the "P" type as a hot junction needed to be cooled and the "N" type as a cold junction needed to be heated. Since the material is actually at the same temperature, the result is that the hot side becomes hotter and the cold side becomes colder. The direction of current also determines which sides get hot or cold. They come is small "blocks" to minimize thermal expansion problems and have power ranges (Qmax) from 15 to 72 watts. There efficiency is difficult to quantify because they "transfer" heat and so efficiency will vary with heat load, but generally they are fairly inefficient. { eg a module having a Qmax capacity of 72 watts requires 15.5 volts at 8.5 amps to run (132 watts). These devices will work in the reverse application as well, that is to convert thermal energy into electricity - known as the **"Seebeck effect"**. The device is inefficient used this way too, and only finds uses in powering spacecrafts electronic system's which have little or no solar energy for running PV cells and other obscure applications.

Evaporative cooling has been used for centuries, the Egyptians used this principal as did the Indians. { It was probably first discovered when some man got "hot" and sweated, - a woman "perspires"}. The system used a cloth or bamboo curtain hung across one end of a room which caught the prevailing breeze or the natural air circulation. Water was dripped down on to the "curtain" which evaporated to provide cooling. (same process as a refrigerant boiling or evaporating - incidently water has a very high energy capacity compared to all the refrigerants - 1060 BTU / lb). This system works well in areas where the climate is one of "dry" heat as it increases the humidity level in the process of cooling. On a humid day they tend to make things more uncomfortable however. Australians used this principle with the "**Coolgardie safe"** , it kept meat and butter cool by the evaporation of water on a hessian curtain around the box. Mexicans would also use evaporative cooling by providing a fountain in a common area in which some water would spray up and "evaporate" to provide a cooling effect for the adjacent buildings. The modern evaporative cooler for household use consists of a box with a water reservoir and a "curtain" that water is allowed to drip down upon. A blower / fan pushes the air out through the curtain to cause it's evaporation. They are usually on a trolley that can be moved to a window space or doorway to suck air in and promote the buildings ventilation as well.

Ice chests or "esky's" are very common because they are an easy solution to camping out for a day or two. "Party" ice is available at many fuel stations, but you may have to hunt around for the longer lasting "block" ice. Dry ice is even better if you can get hold of it. The esky keeps the contents cold by thermally insulating the inside storage from the exterior. Heat is transmitted by convection , conduction and radiation, so if none of these were allowed the storage compartment would remain cold indefinitely.

Thermal energy transfer takes place as a consequence of a temperature differential. Thermal conduction is the transfer of kinetic energy on the molecular level where colliding molecules exchange energy. Generally good electrical conductors are good heat conductors because they have a lot of loosely held outer electrons within their structure which can transfer energy about. Electrical insulators and heat insulation have a stable structure with few energy carriers. Convection transfers energy as a result of the change in density of the medium. For example when air is heated it becomes less dense and therefore lighter than colder air, so it rises. The air that moves carries the energy with it and is transfered to something else (cooled) via conduction or radiation. Radiation of heat occurs when "infrared" electromagnetic waves are emitted. This occurs because when charges and fields of atoms are accelerated in motion a corresponding electromagnetic field is produced. This also works in reverse where atoms can absorb electromagnetic waves of the appropiate "quanta" to change their energy state. (See PV cells).

Refrigerators are an extension of the esky with a cooling device that comphensates for any heat gain within it because of the inefficiencies in it's insulation. (or people opening the door etc, and thermal load of the food)
To provide good thermal insulation the food compartments surrounds need to be insulated with a material such as "fiberglass wool bats" or a "foam" which has a high R value. This value is derived from the thickness of the material / the materials thermal conductivities. Fiberglass batting 3.5 inches thick will have an R value of 10.9 , which is 10.9 ft2 . F . h/BTU . Air circulation from surface to surface is low because of the nature of the material and so convection isn't a problem. Conduction and Radiation are also low because the material is a good thermal insulator. Additional insulation is provided by an exterior surface and the air layers from material to material . A good lid and particularly the seal is also very important in keeping heat out, as is the overall design like the chest freezers that won't let the cold air pour out when the door is opened. (hot air is light , cold air "heavy" which means an upright freezer with a side door will lose the cold air when it is opened). If you are creative and may wish to try, It may be possible to build a "super" esky that will only require a top up of ice every 1-2 weeks and provide for the households refrigeration needs, perhaps fibreglass with very thick foam and careful attention to the lid or door design.
I saw a magazine run a competition which featured a winning article; "Using a freezer as a fridge", {Renew, issue 74}. This idea has merit because it uses a "chest freezer", designed with more thermal insulation and better overall thermal design (chest type) than a fridge, to do much less work than it normally is designed for - thereby being very efficent. The freezers thermostat was change so the compressor would cut out when "fridge" temperatures were reached which provided a fairly economical fridge to run from a solar installation. (article quoted - 500Whr /day), (a mechanical fridge thermostat could be used instead of the electronic, if you wish; and it would use no power. - (the article was mainly about an electronic thermostat) .

The **"Dewar" flask or "thermos"** is a good example of an efficient thermal storage. It is a container within a container with both inner surfaces "silvered" to minimize radiation heat gain / loss. The inner compartment is evacuated of air so no convection can take place. As it is a container within a container only connected and supported at the neck, conduction is minimal.

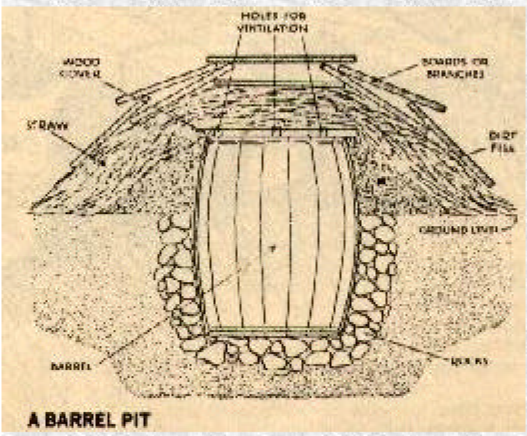
Crosley icyballs were manufactured by the Crosley Radio corporation in USA. This was a patented device (1927) which consisted of two steel spheres which were interconnected with a steel pipe. Ammonia and water were in one side with the other empty. The ammonia and water sphere was slowly heated on a stove to allow the ammonia vapor to rise and condense into the other sphere, which was now sitting in a tub of water. (It had to be heated slowly so very little water vapour was transferred over for good operation). After 1.5 hours or so the heat could be removed and the hot end immersed in the tub of water. The unit was then placed in a special ice chest with the liquid ammonia sphere inside and the other end "outside". The ammonia would evaporate with the absorption of heat and be reabsorbed into the water on the other side. The unit would make ice cubes and provide the necessary refrigeration for a household for 24 hours or more. I read that a unit was found and tested after 70 years and worked flawlessly. This link provided by the "Crosley Automobile club" will provide information on the "icy ball" and how to build one (by Larry Hall), it is well worth looking at.
http://www.cac.crosley.net/IcyBall/crosley_icyball.html.

An idea also worth trying would be to charge a "home brew" one of these with a parabolic solar concentrating dish. Not as good as a fridge but it's free and would be very very reliable if you build it properly. It may be a good idea to have 2 icyballs , so you could rotate them so when one is charging the other could be working. { and you could give them a scratch and a rub too.} - The home built version uses a valve in the middle to hold the process until you need it. My version of this can be found here. (soon)......

Cold Packs absorb heat by starting an endothermic chemical reaction. The most common sort use ammonium nitrate which is held in a tube or sac which is surrounded by water, the whole thing is is a heavy plastic bag. When the cold pack is started (via instructions - perhaps a twist or hit), the ammonium nitrate is released into the water which then produces a "cold" of about 1.5 deg C for about 15 minutes.
Another very endothermic reaction takes place between barium hydroxide and ammonium nitrate which will absorb heat rapidly from it's surroundings to freeze water very quickly

These things may be ok for a "day out" but are not realistic for long term refrigeration needs.

"Cooling cupboards" and "cellars" are practical storage places for "root crops" like potatoes, carrots, turnips, beetroot, as well as apples etc. When constructing a cellar adequate ventilation is necessary to prevent "mould". If damp conditions exist cross ventilation will be necessary. The temperature should be around 2 -20 deg C all year round. Exclusion from the light helps retard the ripening process and the use of shelves and "bins" is a practical solution to storage. Periodic checking is wise to remove any ripened produce before it sends the "rest" bad. Barrel pits (below) are suitable for root crops and apples. Where frost or freezing temperatures may exist adequate insulation is required to stop freezing.



A BARREL PIT

Types of Preservation

"Drying or de-hydration" of fruit and vegetables . Fruit needs to be fresh, unblemished for "drying". Wash, peel, core and cut fruit into small pieces. Slice or quarter apples, peaches, and pears. Plums may be dried whole or cut into halves and stoned. Place small pieces into trays or racks in the sun. A warm or hot breeze will help, and the smaller the pieces the shorter the drying times. Turn the fruit once or twice a day. It is ready for storage when the outside is dry , and is still pliable but not brittle, with no juice left. Oven drying from 110-150 deg F for about 4 to 6 days is also ok. Store dried fruit in tightly tied brown paper or plastic bags in a screwed bottle or biscuit tin in a cool stop. Vegetables need to be blanched before drying. This stops the ripening process and sterilizes the food and prevents colour change. Blanching should well heat to the centre, and can be done by dropping into boiling water for several minutes or by using steam (steam holds more nutritional value) until "limp". Vegetables should be dried until they are brittle and crisp and show no trace of moisture in the centre. Potatoes can be sliced into "chips" or coarsely grated, blanching will stop any colour change. Celery can be cut into thin sticks, the leaves can also be dried (separately) after blanching, Grind down to make a celery salt. Mushrooms can be strung on a thread separated by brown paper etc. Hang above the fireplace or oven or sun dry, they will take several days and are ready when "stiff". A crude flour can be made from grinding up dried broad beans or potatoes. Other ground up vegetables such as celery, carrots, mushrooms, turnips, parsnips, make a good flavoring for soups etc. (Hygiene is always important, keep

the whole process out of the way of ants, flies etc).
Most bacteria die or become inactive in dried or de-hydrated food and will keep for some time stored in air tight container. This process does change the taste and appearance of the food into something completely different.

Salting is used in preservation because it draws out the moisture and will kill or make it difficult for bacteria to live. It has been used for centuries for meat preservation. The process is still commonly used today to produce "country hams" and "corned beef". - prepared by boiling or soaking in a brine solution. Meat jerky - is the best way to preserve game meats and fish in survival situations. Cut off all fats and cut flesh into thin strips. Salt the flesh by rubbing the salt into it or by using a tenderizing hammer or smooth stone while salting. String the strips on a wire or line above a smoky fire to keep the flies and insects away. The smoke helps to cure and flavour the meat and will last for several weeks. (For safety it can be re-dried and smoked each day.)

Bottling fruit is another way to preserve. EVERYTHING must be sterilized to prevent food poisoning. Fruit can be stored in water or syrup made from sugar or honey, and then boiled for several minutes. Vegetables can be bottled too, but EXTREME care is required to halt any bacteria. (30-90 minutes in a pressure cooker depending on vegetable type). Food must be heated above 240 deg F, so are the bottles, caps, utensils etc.

Pickling was used extensively to preserve meats, fruits and vegetables in the past. It is difficult to find much produce today short of pickled onions or "pickles". This process uses the preservative qualities of acids and "salting" which make life difficult for bacteria to survive.

Pasteurizing is a process in which the food temperature is raised to a point which kills all the bacteria and "spoiling" enzymes. This allows the food to be kept for considerable times in sterile containers. This process will significantly alter the taste and nutritional value of the product. Milk can be pasteurized by heating it to 63 deg C (145 deg F) for 30 minutes or to 73 deg C (163 deg F) for 15 seconds. UHT (ultra high temperature) milk is processed by heating to 140.5 deg C (285 deg F) for a few seconds which kills all the bacteria. This milk can be stored unrefrigerated. Fruit juices, ice cream, beer etc are other examples of produce that can be pasteurized.

Carbonation is a process which dissolves carbon dioxide under pressure into water. This eliminates oxygen which bacteria need for life, however they can survive in very low oxygen levels. "Soft" drinks etc have an inbuilt preservative.

Irradiation is becoming common practice for food preservation. It is claimed to be "safe" and doesn't change the taste or appearance of food. I personally avoid such products because I have a "hang up" over such things, and prefer to buy naturally ripened fruit and produce which hasn't been stored for very long, but this is getting harder . . . .

Chemical preservation is another thing I try to avoid (more hang ups) , these products either inhibit or kill bacterial activity. Benzoates - sodium benzoate, Nitrates - sodium nitrate, Sulphites - sulphur dioxide, sorbic acid. are examples which are added to the product to preserve it.

Some Cool Links . . . .

Crosley Radio Corp. - The crosley refrigeration device with links to build your own.

NH3 Com. - J Patrick Johnson's Anhydrous Ammonia information, history, etc.

ASTI - Ammonia saftey training institute, with more info on NH3

Aire Kool. - An article on refrigeration

Homepower - How to build a solar trough Ammonia Absorption Icemaker - Steve Vanek

ACS Electronics - An article on parabolic dishes

Refrigerant supply inc - good refrigerant reference pages.

ICOR international - a PDF engineering supplement on refrigerants.

ASHRAE - Ammonia as a refrigerant ?

Some Human History ; -

Farming practices brought with it a more sedentary existence (compared with nomadic hunting). This brought a richer material existence where work was not a necessary evil like it is looked upon today, rather it was seen as a commitment to the family and community. Output was geared to the family and communities needs with no surplus required, so fewer hours of toil were needed. Far more leisure time was enjoyed by these "tribesman" than we have today. With the increase in community numbers came with it politics, religion and trade, and with that came the monetary systems, opportunities of power and wealth, wars and conquest. Cities were now able to establish away from the fertile farming areas and depended on trade for their lifeblood.

The "industrial" revolution had it's foundations laid in technological advances in science and a "commerce" revolution which financed everything from an explosive expansion of trade. Wealthy capitalists in England financed huge ventures around the world which started an unprecedented change across the world. The material culture was about to change more in the next 2 hundred years than in the preceding 5 thousand years. At this point the "putting out" system where a producer sold his goods to the consumer changed, and a middle man was used. (The capitalist entrepreneur) The creative entrepreneur increased demand and production even further, and with it came a declining standard and longer working hours for the workers. This increased production from it's efficient exploitation of human and natural resources on a worldwide scale saw Great Britain increase it's capital from 500 million pounds sterling in 1750 to 6,000 million in 1856. The colonies all around the world were feeling it's bite which led to some "revolutions" , and after world war 2 many colonies became independent states. The world was dominated by several "superpowers" but world trade and capitalism quickly dismantled many of these trade barriers. (East/West Germany, Russia's closed politics,). At some point corporations were granted equal rights of that of an "individual" in the USA courts which has helped project them into very powerful entities. The need to expand the shareholder's profits to greater heights has brought with it many parallels with the start of the industrial revolution. Today many corporations have more wealth and power than most nation states. . . . . .

So to put the slant back on refrigeration, before the 1800's there were no refrigerators. The great need was there ever since "surpluses" were required for trade or to get through "long droughts etc", but mechanized refrigeration was born out of technology and industrial revolutions. Many precursors were required, in fact if it wasn't for many of our dark qualities , ie ,"greed" we may still be stirring cook pots in smoky caves. - {one of those bitter / sweet pills . . . .}. We managed without refrigeration for thousands of years however, and farming and local trade provided all the fresh produce needs, and people lived (occasionally long) healthy lives, (If they could avoid plagues and disease, wars and pay the kings often heavy taxes) - . . . . . . .bit like "today" really ?.

SOME NOTES :-

Stated above for simplicity was that the refrigerant "boils off", but strictly speaking boiling temperatures are measured at 1 atmosphere. The boiling or flash temperatures done at some different pressures is known as the "saturation temperatures". The "critical temperature" of a refrigerant is the temperature above which increasing pressure cannot liquefy the vapor alone, and as temperature goes hand in hand with pressure, there is a critical pressure which a refrigerant exists as a vapor in equilibrium with the critical temperature..

Ammonia, NH_3, is not used in public places because of the health risks. If a leak should develop in significant quantities it can be fatal. Ammonia was used without to many accidents in homes for many years however. Your nose can detect approximately 5 ppm with concentrations of over 100 -200 ppm for eye irritation and over 2400 ppm for 30 minutes to probably cause death, so you will be warned well before trouble, (usually). BE CAREFUL, the vapor is lighter than air, but not much is needed to fill a room to lethal concentrations within seconds, experiments should be carried out outside. . . ! . Ammonia will quickly corrode copper, aluminium, zinc etc or their alloys, use cast steel or iron, steel, or stainless steel. Most plastics are also ok for check valves etc.

Ammonia has a good heat of vaporization. 1369 kJ / kg (or 589.3 BTU / lb). This means it has a high energy capacity. In fact it is 9 times better than R12 or R22 , etc (they are around 65 BTU / lb) so these refrigerants would require a compressor to pump the quantity of gas around 9 times for the same energy transfer as the same quantity of ammonia going around once. (Think of the mechanical energy).
Ammonia is ozone friendly in the atmosphere and breaks down after several days .- **kind of makes you wonder why we ever abandoned it for that other stuff. . . commercial reasons??**
(Propane is also an extremely good refrigerant, and overlooked because it is a good explosive also, but with additives this risk can be minimised - **Warning this is for information only, DON'T TRY - you or others may be blown up!)**

Newer refrigerants have short atmospheric lifetimes, but they still do damage to our atmosphere in that time. This is however far better than using something like common ol' R-12 (freon 12 etc) that has an atmospheric lifespan of 100 years, some are even worse. Don't let the charge in the car air conditioner just keep leaking away, and every year you top it up!, get it fixed. Also ensure your gas from any fridges or airconditioners are re-claimed and recycled. Better yet, if you can live without airconditioners don't buy one. . . . .

Do's and Don'ts. - Food and Refrigeration. . . . .

With hot weather it is important to keep potentially hazardous foods cold from the shopping trolley to your refrigerator. In a very short time without refrigeration bacteria will multiply and spoil your food.

Shop when it's the coolest - in the morning or late in the evening
Don't leave food (Children or pets) in the car during the day (Aust. temps can get as high as 60 deg C within 15 minutes in there.)
Shop for the frozen or refrigerated foods last.
Do not choose foods with broken or torn packages as it may be contaminated.
Pack cold items together at the checkout, (plastic bags tied at the top can become a mini-esky).
Separate meats, pack other cold stuff together, put glass products in one bag so it can get special "gentle" attention.
Take the food straight home from the shops.
Do your "running about" , pay bills etc, before you shop for food.
If you have a long trip home bring an esky with an ice pack or similar to keep the cold and frozen foods "cold" (even if it's a short trip ?).
Once home, refrigerate "cold" foods immediately. Leave foods in their original sealed packages.
Keep your refrigerator's internal temperature of 3 deg C (38F) or lower, (freezer at -17 deg or lower).

Summer and Food Safety - The hot weather is a good time to have a BBQ but it provides a good environment for bacteria and other pathogens in food to multiply rapidly and cause illness. Wash Your Hands before and after handling food to reduce contamination and the spread of bacteria.

Marinating - When marinating for long periods of time, it is important to keep foods refrigerated. Don't use sauce that was used to marinate raw meat or poultry on cooked food. Boil used marinade before applying to cooked food.

When grilling foods, preheat the coals on your grill for 20-30 minutes, or until the coals are lightly coated with ash. Use a meat thermometer to insure that food reaches a safe internal temperature, especially for "rare" cooking of meats.

When taking foods off the grill, do not put cooked food items back on the same plate that previously held raw food.

A full ice chest / esky will maintain its cold temperatures longer than one that is partially filled so it is important to pack plenty of ice or freezer packs to insure a constant cold temperature.

Refrigerator use and care -

* Buy and use the best energy rating refrigerator you can, dispose of the old one properly - (have the refrigerant removed and stored professionally before dumping).
* Install it in a cool section of the house, out of breezes, away from sunlight (but ensure the "back condenser coils" can ventilate)
* Operate it at 3 deg C and -17 deg C or better in the freezer.
*Frost free types use extra energy, - perhaps you can live without this feature?
* Go to the refrigerator as little as possible to reduce the heat gain into the fridge.
* Keep it clean of mold and mildew, remove old food, defrost it when ice starts to interfere with "seals" etc.
* Maintain the door seals in good order, and always make sure it closes properly - a lot of heat is absorbed through bad seals.
* Consider "chest" type fridge and freezers as these types inherently keep the "cold" air "in" better.
* Consider the smallest size refrigerator that will forfill you needs, (a full fridge operates at it's most efficient - fill unused space with bread?).
* During blackouts, don't open the fridge or freezer at all to conserve the "cold".
* If you see the house lights on, but lit dimly, you may have low voltage power applied to the fridge which will damage the motor, switch it off until power is restored fully. Don't forget to switch it back on though. . .
* White is the best colour to reflect light and heat, don't repaint the fridge a "cool" deep blue or black. (this will absorb heat)
* Occasionally check the internal temperature of the refrigerator and check the thermostat hasn't been moved or knocked from it's proper setting.

Shopping for a fridge: -

There are literally hundreds of brands and different sizes of refrigerators to choose from. You should work out your requirements before hand, like "internal capacity" in litres you need, your energy supply (gas, 12/24v etc, 240 vac), any special features. 240v ac types are fairly efficent these days but choose one with a good energy rating. If you can live without frost free features this will save you in energy costs, but the trade off is the rotten defrosting occasionally. Kerosene fridges are still available "new" and work very well. About 14 litres of kero will keep a 220 litre fridge going for about 2 to 3 weeks, (depending on heat load). The same size fridge running on LP gas will use about 20g / hour (or optional 320 watts of 240vac electricity) and performs well too. Smaller fridges are available running on any of the available energy sources but some of these use thermoelectric modules instead of "compressors" and have the advantage of running silently. Many can run from any supply - gas / 12v / 240v power supply options which make them very versatile too. The thermo-electric modules are fairly inefficent though with a 35 litre fridge/freezer drawing about 6.25 amps from 12 volts DC (75 watts) or use about 250g of gas per day, or a 60 litre comsuming 160 watts (13 amps at 12 volts DC). A compressor version will always out perform the thermoelectric modules easily.

Probably the most efficent fridge around today uses a "swing motor" made by "Sawafuji" in the "Engel" brand. (Maybe they will give me one for this plug! - tell them I gave it a good wrap! - 1300 302 653) This uses a special solenoid as the compressor which is employed in a resonant circuit and supplied by an efficent switchmode power supply which converts the incoming power (12 / 24 volts DC or 240vac) for it. A 40 litre fridge / freezer will draw about 3.3 amps at 12 volts (40 watts) which out performs even the best conventional compressor driven types and leaves the thermoelectric module types for dead. I have not tried one yet, but I believe the only drawbacks are that they gum up with long term (not in use) storage, and some electronic power supplies are notoriously frail, perhaps these are OK though. . . . .

WARNING - (Using Ammonia and high pressures are two very dangerous activities, either can kill you, taken together it is very dangerous - if you are not skilled in pressure vessel construction, chemistry and physics do not attempt any experiments)

Good luck Chris.

Back to projects page