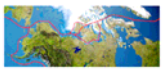
John Franklin (1786-1847)

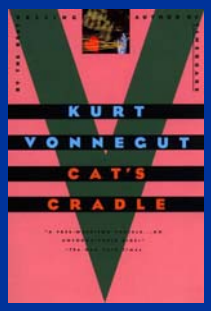
As a British Arctic explorer, he mapped almost 2/3 the coastline of North America

- In 1845, at the age of 59, he set out with 24 officers , 110 men and three years' supplies to chart the Northwest Passage.
- In 1850 the remains of the ships were found along with thousands of bones and a few marked gravesites.
- A century later, the bones were scientifically tested, showing that the crew had most likely died of pneumonia and tuberculosis. Toxicological reports showed the presence of lead poisoning. In addition, blade cut marks on the bones of some of the crew suggested cannibalism. The combination of years of exposure to freezing weather, disease and starvation had killed everyone in the Franklin party.



Cat's Cradle

Ice-nine



When ice-nine comes into contact with water, it instantly crystallizes the entire body of water into ice-nine - thus destroying the world.

Brain Freeze

It just might happen to you!

When the cold object touches the roof of your mouth, the blood vessels contract in response in an effort to prevent loss of body heat. As the coldness recedes, the blood vessels relax again, quickly increasing blood flow to the brain. This sudden release is what causes the intense headache sensation.

*especially painful if the ice cream is cooled with liquid nitrogen

Toddlers Found Frozen to Death After Father's Drunken Escapade

Thursday, January 31, 2008

Canadian Mounties are investigating the deaths of two toddlers found frozen to death on the Saskatchewan's Yellow Quill First Nations reserve earlier this week, the National Post reported.

Santa Pauchay, 1, was found dead Tuesday afternoon and her 3-year-old sister, Cadence, was found Wednesday, both dressed in light tops and diapers, according to the newspaper.

They were found in a snowdrift-covered area of the reserve between their home and that of a neighbor's, the National Post reported.

Their father, Christopher Pauchay, 25, left their home with them sometime after 12:30 a.m. Tuesday without a coat. About 5 a.m. Pauchay showed up at a neighbor's door covered in frost bite and not able to speak, the newspaper reported.

Eight hours later, Pauchay asked about his daughters, according to the Post.

The girls' grandmother — Pauchay's mother — told the newspaper she believes her son was taking the children to his sister's home, and that alcohol was involved.

"He was carrying them. But he was drinking, and he must have blacked out," Pearl Pauchay said. "That's what he said when we went to visit him in the hospital."

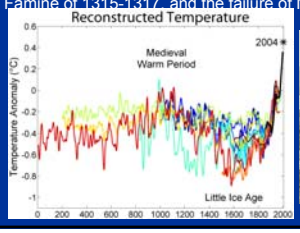
The Royal Canadian Mounted Police have not decided if charges will be filed against Pauchay.

http://www.foxnews.com/story/0,2933,327225,00.html

Little Ice Age

circa 1300-1850

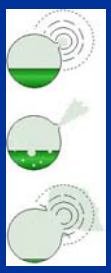
- Minor period of cooling (ΔT< 1K) following the Medieval Warm Period, possibly caused by increased volcanic activity and decreased solar activity (less sunspots)
- The Little Ice Age featured glacier increases, extremely cold winters in Europe and North America, and widespread crop failures.
- Possibly resulted in Icelandic population decreasing by half, the Great Famine of 1315-1317, and the failure of Norse settlements in Greenland



BLEVE

Acronym for **B**oiling **L**iquid **E**xpanding **V**apor **E**xplosion

- Can be caused by :
  - Excess heat that raises the pressure and causes rupture
  - Small rupture that lowers the pressure inside the tank causing liquid inside to become vapor faster then it can be expelled, leading to explosion



Video: http://www.youtube.com/watch?v=9jnGsZ0VP0c

Trains collide, liquid nitrogen fertilzer spilled into Mississippi river

- December 17, 2008, 5:30 a.m. two freight trains collide in Minnesota
- 26 total cars derailed, 31,000 gallons of liquid nitrogen fertilizer dumped
- Fertilizer consisted of 28% liquid nitrogen

- Liquid Nitrogen causes eutrophication (process promoting excessive plant growth and decay) in rivers, which causes:
  - Drinking water contamination
  - Increased water turbidity
  - Depletion of dissolved oxygen
  - Fish mortality

Cryogenic Dewar Leak

- Cryogenic dewars are often used to store chemical products which are gases at atmosphere temperature, some are noxious. (Such as chlorine can cause respiratory disease)
- Liquid will vaporize in room temperature, it will affect both people and plants in large area.
- In transportation and storage, leak can be extremely dangerous to people if it happens in urban place.

A chlorine leak accident occurred at Nanchang, China caused 282 people hospitalized. Residents rush to safe places after leak.

March 1979: Three Mile Island Accident

- A nuclear reactor in Middletown, PA almost melted down due to a lack of coolant.
- A faulty pressure-relief valve was responsible for leaking cooling water from the reactors core.
- TMI was not catastrophic. The reactor Temp. was brought down before the reactor could breach its containment.

Long term health effects of animals and plants exposed to radiation leaked from TMI is still debated.

The Three Mile Island Disaster

The Three Mile Island Nuclear Generating Station near Harrisburg Pennsylvania underwent a partial meltdown on March 28th 1979, releasing over 40,000 curies of radioactive Krypton and as much as 13 million curies of other radioactive gases.

The disaster was caused by a defective valve in the cooling system, allowing coolant to leak out. The reactor overheated and burst, releasing radioactivity into the coolant. Hydrogen gas was produced, filling the cooling system. The accident was eventually brought under control.

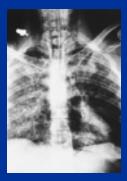
The cleanup from this disaster cost an estimated 1 billion dollars. The disaster also discredited the safety of nulear power production in the public eye, and was likely responsible for the reduction in the amound of new reactors being constructed.

LN2–room TU Darmstadt, 1996

- ventilation above height of head
- Student fills 30 l and 5 l Dewar. While filling second 5 l Dewar he looses consciousness.
- Liquid nitrogen continues to flow
- Student gets frostbites and suffocates.
- After 30-40 min another student finds him, turns off nitrogen and on way to door looses consciousness as well.
- A third student being on the same floor takes him out of the room.

Too much Oxygen?--- Oxygen Toxicity

- A 47-year-old experienced underwater cave diver, with no significant medical history, was diving with two tanks -- one containing compressed air, the other a 50% mixture of oxygen and nitrogen (nitrox).
- After a 19 min dive, he was seen floating head down, unresponsive: "his fins moving as if he was shivering" stated by a witness.
- Cardiopulmonary resuscitation was attempted, but abandoned after 43 minutes due to no response.



- postmortem x-rays and autopsy of the body revealed large amounts of gas in the venous system of the trunk and limbs and in both sides of the heart
- Foamy blood and gas were found in all chambers. Analysis of gas from the right ventricle showed O_2 (20.6% by volume), and N_2 (75.9%).
- There was bruising of the tongue and petechiae on the lungs and heart. The brain (1740 g) showed mild cerebral oedema and a microscopic perivascular haemorrhage in the floor of the fourth ventricle

- *Fig: Postmortem erect chest x-ray, showing gas in both sides of the chest and in the neck veins*

So what exactly happened?

Figure 2: Equipment used by the diver, showing the 50% oxygen/nitrogen gas tank (yellow, right), compressed-air tank (black, left), yellow tape marking the compressed-air circuit, and two-way valve which controlled the source of the air supply

•Examination of the subject's diving equipment re-vealed that he had been breathing the 50% oxygen/nitrogen mixture for most of the dive.

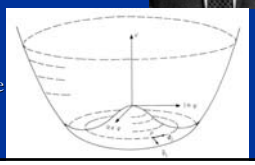
•The cause of death was drowning after **oxygen toxicity**, as determined by the coroner.

•Using a 50% oxygen/nitrogen mixture at 47 m depth, the diver had been exposed to a partial pressure of oxygen of 291 kPa (2.9 atm), possibly for as long as 19 min.

•This gas mixture should be used only at depths less than 14-18 m (depending on the duration of exposure).

BCS: gauge-symmetry VIOLATION

- When Bardeen, Cooper, and Schrieffer published their theory of superonductivity in **1957**, Yoichiro Nambu and others noted that the BCS superconducting ground state lacked the gauge invariance of the underlying electromagnetic theory.
- Nambu concluded that the superconducting ground state results from the spontaneous breaking of the underlying gauge symmetry.



PHYSICS TODAY, December 2008

Superconducting Magnet Quench

- Liquid helium and LN2 are usually used to keep the coils of a superconducting magnet below their critical temperature.
- If part of the magnet goes normal (becomes resistive) this can cause rapid heating and quickly boil off the helium and nitrogen.
- When going from a liquid to a gas He expands to 754 times its initial volume and LN2 expands 694 times.
- This expansion can be dangerous in itself but will also push out all of the breathable oxygen in the room potentially causing workers to asphyxiate.
- These cryogens are particularly dangerous because they are colorless and odorless.

(Magnet after quench)

The K-152 *Nerpa* Accident

- The K-152 *Nerpa* is a Russian attack submarine that was commissioned in October 2008 after a decade of delayed construction.
- In November 2008 the *Nerpa* was undergoing sea trials. It's first underwater test run was November 8.
- At 8:30pm, the fire extinguishing system "went off unsanctioned," causing the front two compartments to be sealed and filled with freon R-114B2 gas.
- 20 men died of asphyxiation, including 17 civilians. 41 more were injured from the effect of the cold gas

Controversy:

- Survivors say the warning sirens sounded only after the gas poured in
- The submarine was overcrowded for the testing and some say there were not enough masks on board
- Some of the breathing kits failed after a few minutes; it was reported that some of the dead were wearing the masks
- The accident was blamed on Dmitry Grobov, who many consider a scapegoat since he was a skilled specialist and it would require more than one person to activate the system

Sources: ABC News Australia, BBC News

Indium Seal Failure

- Task:
  - Test MEMS beam devices in **vacuum** under **low temperature**.
- Why indium seal?
  - Indium creates effective and reliable ***helium*** tight hermetic seals.
  - We coated indium with vacuum grease to prevent it sticking to other metals.

The cryostat with our probe and me

The probe cap, indium and vacuum grease

Indium Seal Failure

- Too much grease caused the indium seal failed but not until the probe was lowered into liquid helium.
- One day later, our signal was gone. But we didn't know there was a leak, and naturally decided to raise the probe to have a look.

I was standing on the cryostat and raising the probe. Suddenly a puff broke the silence in our lab.

The leaked liquid helium in the "hermetic" probe became gas of thousands larger size.
It broke out from the weakest point of the probe – the valve.

The valve where the gas broke through

Natural Gas Goes BOOM!!!

The LNG and LPG is transported by specialized transport ships, as the gas is liquified at cryogenic temperatures.

The New London School explosion occurred on March 18, 1937, when a natural gas leak caused an explosion, destroying the New London School of the city of New London, Texas. The disaster killed in excess of 295 students and teachers, making it the worst catastrophe to take place in a U.S. school building.

Before

After

The Explosion looked something like this...

http://www.youtube.com/watch?v=xxNpz41wSOg&feature=related

October 21,1944 Cleveland, Ohio LNG Explosion

- Tank was being repaired with inferior materials because of the war. A spark ignited the facility causing a massive explosion.
- Accident killed 135 people and injured hundreds more.
- Little known disaster because of World War II.
- Steel was not used in the container because it was wartime and the military required much of the steel in the US. An alloy was chosen and was a cause for the explosion.

Cleveland LNG Disaster 1944

- Cleveland East Ohio Gas Explosion occurred on the afternoon of Friday, October 20, 1944.
- The resulting gas leak, explosion and fires killed 130 people and destroyed a one square mile area on Cleveland, Ohio's east side.
- Vapor from a liquefied natural gas storage tank leak dropped into the sewer lines via the catch basins located in the street gutters.
- As the gas mixture flowed and mixed with air and sewer gas, the mix ignited. In the ensuing explosion, manhole covers launched skyward as jets of fire erupted from depths of the sewer lines.

Liquid Nitrogen Explosion in TEXAS A&M UNIVERSITY

In an incident in 2006 at Texas A&M University, the pressure-relief devices of a tank of liquid nitrogen were sealed with brass plugs.

As a result, the tank failed catastrophically, and exploded. The force of the explosion was sufficient to propel the tank through the ceiling immediately above it.

Frozen Pipeline Workers

1998 – Springer, Oklahoma

" A supervisor making morning rounds Tuesday found the **frozen** bodies of two men who were using **liquid nitrogen** to check the pressure on a pipeline."

"…authorities think one man may have gone into a hole and was overcome by the **liquid nitrogen**"

Liquid Hydrogen Dangerous? Yes

$$\mu_{JT} \equiv \left(\frac{\partial T}{\partial P}\right)_H = \frac{V}{C_p}(\alpha T - 1)$$

Joule-Thomson (Kelvin) effect,

T = 205K

R101 Airship Disaster October 5, 1930

- Due to unstable ballast system, damaged at takeoff, airship was not able to rise high enough off the ground and eventually hit the ground, igniting the hydrogen tanks.
- The loss of life from the R101 crash, surpassed the Hindenburg disaster of 1937, and was second only to that of the USS Akron crash of 1933.
- The demise of R101 effectively ended British employment of rigid airships

Medical Oxygen Fire

- On February 15, 2005 Robert Wright Sr. (age 63). Died in his home when several tanks of oxygen he used to aid his breathing exploded near his bed, fire authorities said.
- The man had emphysema and was a heavy smoker.
- The explosions of the oxygen tanks shot chunks of Wright's bedroom windows 25 feet across the complex's parking lot.
- "I set off a stick of dynamite once, and it seemed like this was twice that," a witness said.

Cryogenic disasters

MRI explosion in Atlanta

In December 2006, an MRI machine exploded during transport, due to a liquid nitrogen leak:

Two workers moving the machine were injured after the explosion blew part of the machine into a wall. The workers were moving the machine at Atlanta Diagnostic Center in Kennesaw.

Liquid nitrogen leaked from the machine and caused the blast, knocking a 10-foot by 10-foot hole in the wall.

The MRI machine has an end bell, which has helium and liquid nitrogen. The pressure from the helium made the end bell come off, and it hit a wall.

The end bell that blew off did not hit the workers. it was just all the debris from it.

One man had shrapnel in the back of his head. Another man injured his arm. They were taken to the hospital with non-life-threatening injuries.

MRI Explosion

- Took place in Salisbury, Maryland in 2006.
- A MRI exploded while preparing it for transfer.
- Initial reports say that the explosion was due to the venting process.
- Later reports say that there was a buildup of ice in the venting lines and around the pressure sensor that would release the pressure if it got to high.

Link to local news video report

HVAC Trane XL1200 Recall

-Compression failure caused almost all of these air conditioning units to stop works

-Failure was caused by moisture.

-Water would seep onto the compressor and the temperature of the compressor and materials used by the compressor made acid with the moisture, causing holes

Cryogenic Disasters

Don't Try This At Home

- Why you should never make Ice Cream with Liquid Nitrogen **in a Blender.....**
- http://www.youtube.com/watch?v=BTqXcJC-b44

Young David Tanner

Liquid Nitrogen and Hot Oil Do Not Mix

What Happented on 7/21/97:
An oil bath caught fire within a fume hood. A post-doc attempted to extinguish the fire using liquid nitrogen. As the liquid nitrogen came into contact with the oil, an explosion sent the hot oil in all directions. This caused first and second degree burns to the face and head, and third degree burns to the right hand (the one used to pour the liquid nitrogen).

09/1/18

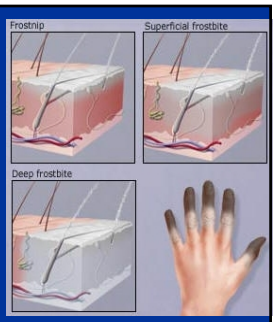
Death Caused by Nitrogen Asphyxiation

-- New York Times

- December 9, 2000; Dayton suburb of Bellbrook, Ohio
- Three nursing home residents died among seven taken to hospital. Victims were 70, 76 and 77 years old.
- There was a mix-up that allowed nitrogen to be hooked up to an oxygen system.
- A nitrogen tank may have been mistaken for an oxygen tank because the tank had an oxygen label partially covered by a smaller nitrogen label.

Frostbite

- Frostbite refers to the freezing of body tissue, that results in loss of feeling and color in the tissue.
- People working in laboratories should take precautions as liquid nitrogen and other cryogenic liquids can cause frostbite even with brief exposure.
- Gloves (even ones designed for cryogenic work) will not provide protection from immersion in liquid nitrogen. If the glove is wetted with the liquid, it will soak in and freeze your hand inside the glove.



Three different degrees of frostbite: frostnip (top-left), superficial frostbite (top-right), and severe/deep frostbite (bottom-left).

Space Shuttle *Columbia* disaster

- on February 1, 2003, when the Space Shuttle *Columbia* disintegrated during re-entry into the Earth's atmosphere, with the loss of all seven crew members.
- Incidents of debris strikes from ice and foam causing damage during take-off were already well known, and had actually damaged orbiters. Tile damage had also been traced to ablating insulating material from the cryogenic fuel tank in the past.

Disasters in Cryonics

9 accidents since 1969

- Several patients under the care of the Cryonics Society of California were thawed when consolidated to fewer capsules to conserve funding for solid carbon dioxide.
- Other individuals where thawed and reburied when funding was ceased by their living relatives.
- Patients at the Chatsworth, CA CSC site were neglected or improperly preserved which resulted in thawing.
- Robert Nelson, the president of the CSC was sued by relatives of the patients under his company's care and was execrated as a conman and a mass murderer by the cryonics community.
- The CSC site Chatsworth became a byword for cryonics disaster.
- Some of the patients that were frozen had been dead and stored at temperatures above freezing for extended periods of time, even up to a year.

CRYONIC FAILURES

-In the early days of Alcor Life Extension Cryonics, the stored bodies of the frozen had to be periodically pumped to both keep the vacuum and vent the pressure of the liquid nitrogen.

-In 1974, two bodies, that of Steven Mandell and a 6 year-old-boy, both suffered thawing and re-freezing from failure to sustain a vacuum around the capsule.

-Essentially, the Cryonic Technicians failed to maintain a large Dewar Flask.

-Hopefully Ted William's head will do better.

* All information and images obtained from the Alcor website.

ALCOR logo

Steven Mandell (alive)

Chatsworth Disaster

- Cryonics is low-temperature preservation of humans and animals that can no longer be sustained by contemporary medicine until resuscitation may be possible in the future.
- 1979 it was discovered that nine cryonics patients who were supposed to be maintained in liquid nitrogen had not been kept up and all the bodies were badly decomposed.

Information taken from http://www.benbest.com/cryonics/history.html and wikipedia.com

Possible Future Cryogenic Disaster!!!!

- Eliezer Yudkowsky of *www.overcomingbias.com* reports Paris Hilton has signed up for cryo-preservation with her pets at the Cryonics Institute.
- Several other media outlets agree, including www.socialitelife.celebuzz.com
- Paris has denied signing up for cryonics on Ellen.

Cryosurgery Disasters

There are some instances where cryosurgery has resulted in a much bigger issue to the patient. The examples below are such disasters.

Oedema following cryosurgery to a left temple basal cell carcinoma.

Granulating wound with some necrosis following liquid nitrogen spray cryosurgery for a large basal cell carcinoma.

Cambridge Electron Accelerator Explosion

- 3:32 A.M. on July 5, 1965
- Liquid Hydrogen was utilized as the working fluid (approx. 500 liters) in the exploded Bubble Chamber
- Eight were injured as a result