



SCIENCE DISSECTED

Which is the lesser of 2 evils: paper bags or plastic bags?

Model-Evidence Link Diagram (MEL)

Many have thought that paper is better for the environment than plastic bags. Paper or plastic has been a controversy that has been going on for decades with no definitive answer in sight. As time has progressed so has the technology; this MEL explores facts and possible solutions that observation and research has provided thus far.

Model A: *The impact of plastic bags on the environment can be devastating.*

Model B: *Although paper bags have a higher recycle rate than plastic bags, they are as devastating for the environment.*

Evidence #1: Data shows that plastic bags are ‘sacking’ the environment. However, plastic bags are economical and environmentally acceptable if use is regulated.

Evidence #2: According to authorities, paper bags are as bad, or worse, for the environment as plastic bags.

Evidence #3: The success of the plastic bag has meant a dramatic increase in the amount of sacks found floating in the oceans where they choke, strangle, and starve wildlife.

Evidence #4: Many do not know that it takes as many as 4 times as much energy to manufacture a paper bag.

The following is a suggestion for using this MEL with students:

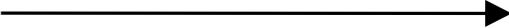
1. Hand out the Paper vs. Plastic bags Model Evidence Link Diagram (page 1). Instruct students to read the directions, descriptions of Model A and Model B, and the four evidence texts presented.
2. Handout the four evidence text pages (pages 3-12).
3. Instruct students to carefully review the Evidence #1 text page (page 3), then construct two lines from Evidence #1; one to Model A and one to Model B. Remind students that the shape of the arrow they draw indicates their plausibility judgment (potential truthfulness) connection to the model.
4. Repeat for Evidence #2-4 (pages 4-12).
5. Handout page 2 for the students to critically evaluate their links and construct understanding.

Once students have completed page 2, they can then engage in collaborative argumentation as they compare their links and explanations with that of their peers. Students should be given the opportunity to revise the link weighting during the collaborative argumentation exercise. If time permits, have students reflect on their understanding of paper vs. plastic bags and create questions that they might explore in the future.

Name: _____ Period: _____

Directions: draw two arrows from each evidence box. One to each model. You will draw a total of 8 arrows.

Key:

	The evidence supports the model
	The evidence STRONGLY supports the model
	The evidence contradicts the model (shows its wrong)
	The evidence has nothing to do with the model

Standard: L.8.C.3

Evidence #1
Data shows that plastic bags are 'sacking' the environment. However, plastic bags are economical and environmentally acceptable if use is regulated.

Model A
The impact of plastic bags on the environment can be devastating.

Evidence #3
The success of the plastic bag has meant a dramatic increase in the amount of sacks found floating in the oceans where they choke, strangle, and starve wildlife.

Evidence #2
According to authorities, paper bags are as bad, or worse, for the environment as plastic bags.

Model B
Although paper bags have a higher recycle rate than plastic bags, they are as devastating for the environment.

Evidence #4
Many do not know that it takes as many as 4 times as much energy to manufacture a paper bag.

Provide a reason for three of the arrows you have drawn. **Write your reasons for the three most interesting or important arrows.**

- A. Write the number of the evidence you are writing about.
- B. Circle the appropriate descriptor (**strongly supports** | **supports** | **contradicts** | **has nothing to do with**).
- C. Write the letter of the model you are writing about.
- D. Then write your reason.

1. Evidence # ____ **strongly supports** | **supports** | **contradicts** | **has nothing to do with** Model ____ because:

2. Evidence # ____ **strongly supports** | **supports** | **contradicts** | **has nothing to do with** Model ____ because:

3. Evidence # ____ **strongly supports** | **supports** | **contradicts** | **has nothing to do with** Model ____ because:

4. Circle the plausibility of each model. [Make two circles. One for each model.]

	Greatly implausible (or even impossible)										Highly Plausible
Model A	1	2	3	4	5	6	7	8	9	10	
Model B	1	2	3	4	5	6	7	8	9	10	

5. Circle the model which you think is correct. [Only circle one choice below.]

Very certain that Model A is correct	Somewhat certain that Model A is correct	Uncertain if Model A or B is correct	Somewhat certain that Model B is correct	Very certain that Model B is correct
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Evidence #1: Data shows that plastic bags are 'sacking' the environment. However, plastic bags are economical and environmentally acceptable if use is regulated.

Are Plastic Grocery Bags Sacking the Environment?

John Roach
for National Geographic News
September 2, 2003

The "paper or plastic" conundrum that vexed earnest shoppers throughout the 1980s and 90s is largely moot today. Most grocery store baggers don't bother to ask anymore. They drop the bananas in one plastic bag as they reach for another to hold the six-pack of soda. The pasta sauce and noodles will get one too, as will the dish soap.

Plastic bags are so cheap to produce, sturdy, plentiful, easy to carry and store that they have captured at least 80 percent of the grocery and convenience store market since they were introduced a quarter century ago, according to the Arlington, Virginia-based American Plastics Council.

As a result, the totes are everywhere. They sit balled up and stuffed into the one that hangs from the pantry door. They line bathroom trash bins. They carry clothes to the gym. They clutter landfills. They flap from trees. They float in the breeze. They clog roadside drains. They drift on the high seas. They fill sea turtle bellies.

"The numbers are absolutely staggering," said Vincent Cobb, an entrepreneur in Chicago, Illinois, who recently launched the Web site <http://reusablebags.com/> to educate the public about what he terms the "true costs" associated with the spread of "free" bags. He sells reusable bags as a viable solution.

According to Cobb's calculations extrapolated from data released by the United States Environmental Protection Agency in 2001 on U.S. plastic bag, sack, and wrap consumption, somewhere between 500 billion and a trillion plastic bags are consumed worldwide each year. Of those, millions end up in the litter stream outside of landfills—estimates range from less than one to three percent of the bags.

Laurie Kusek, a spokeswoman for the American Plastics Council, said the industry works with its U.S. retail customers to encourage recycling of plastic bags, which are in high demand from companies such as Trex in Winchester, Virginia, for use in building materials.

"We also feel it is important to understand that plastic grocery bags are some of the most reused items around the house," she said. "Many, many bags are reused as book and lunch bags as kids head off to school, as trash can liners, and to pickup Fido's droppings off the lawn."

But like candy wrappers, chewing gum, cigarette butts, and thousands of other pieces of junk, millions of the plastic bags end up as litter. Once in the environment, it takes months to hundreds of years for plastic

bags to breakdown. As they decompose, tiny toxic bits seep into soils, lakes, rivers, and the oceans, said Cobb.

Plastic Fantastic

The Film and Bag Federation, a trade group within the Society of the Plastics Industry based in Washington, D.C., said the right choice between paper or plastic bags is clearly plastic.

Compared to paper grocery bags, plastic grocery bags consume 40 percent less energy, generate 80 percent less solid waste, produce 70 percent fewer atmospheric emissions, and release up to 94 percent fewer waterborne wastes, according to the federation.

Robert Bateman, president of Roplast Industries, a manufacturer of plastic bags—including reusable ones—in Oroville, California, said the economic advantage of plastic bags over paper bags has become too significant for store owners to ignore. It costs one cent for a standard plastic grocery sack, whereas a paper bag costs four cents, he said.

Evidence #2: According to authorities, paper bags are as bad, or worse, for the environment as plastic bags.

Paper Vs. Plastic Bags?

By Rachel Decker and [Anders Graff](#)

For [Dr. Candice Bradley](#) Ecological Anthropology 36

[Lawrence University](#)



We've all been in the grocery store, at one time or another, and been asked, "Paper or plastic?" Do you remember which you chose? Moreover, why did you make that particular choice? And, was it an informed decision?

In our era of ecological and environmental awakening, the question of paper or plastic bags should be taken, and considered seriously. Everyone uses bags; Everybody has this choice. Why do we have a choice? It is a question of environmental impact, and it should be the responsibility of us all to make the most ecologically aware, and sound decision.

This homepage is an exploration of, and an attempt to answer, the question of which, indeed, is the better choice, paper or plastic bags?

Where it comes from: Paper.

Paper comes from trees, and the pulpwood tree industry is large. It begins with logging, where select trees are found, marked, and felled. After they're cut, roads are built into the forest on which the large machinery, used to load and transport the timber, can be moved. This process creates a tremendous scar in the forests natural habitat(s), for both plant and animal. It can take over a century for nature to recover from even a small logging operation. Addedly, if the small operation clears only 10 acres, many hundreds of acres surrounding are affected due to the extreme interplay/interdependency in nature.

Let it be added further that a large amount of heavy machinery is used, all having its own story on how it came to be, all needing its own upkeep, and all needing its own fossil fuel, to operate.

On top of this, there is the human element. Logging is dangerous. Extreme fatigue, long term physical handicaps, and numerous accidents plague the less-than-wealthy loggers.

Logs are moved from the forest to a mill. Whence they reach a mill, there is a three year wait before they can be used, allowing proper drying. When the time comes, the logs are stripped of bark, and chipped into inch-wide squares. They are stored until needed, and then cooked with tremendous heat and pressure. After this, they are "digested" with a limestone and sulphurous acid for eight hours. The steam and moisture is vented into the outside atmosphere, and the original wood becomes pulp. For every ton of pulp made it takes over three tons of wood, initially.

The pulp is washed and bleached, both stages requiring thousands of gallons of clean water. After this, coloring is added to more water, and is then combined in a ratio of 1 part pulp to 400 parts water to finally make paper. The pulp/water "brew" is dumped onto a web of bronze wires, the water showers through, leaving the pulp, which, in turn, is rolled into finished paper.

It must be noted that this is the paper making process. All cutting, printing, packaging, and shipping, requires additional time, labor, and energy, on top of the already exorbitant amounts of capital, electricity, chemicals, and fossil fuels used.

Where it comes from: Plastic.

Plastic comes from oil, and the oil industry is no small operation. In many places around the world, and in the U.S., sites exist where the geologic conditions are such that a gas and oil concentration has been trapped. Upon location of these traps, a hole is drilled and a pipe rammed into the oil deposit. The oil is pushed to the surface due to pressure in its chamber, and also from the weight of earth above. The oil drilling operation, itself, has become a rather small and sterile undertaking. An oil drilling/pumping rig is roughly the size of a house, and very little oil is spilled, anymore. Literally, you could 'mine' oil in your backyard.

At the drilling site, a storage drum is filled, and, when full, the content oil is loaded into trucks, but sometimes piped, to a refining facility. This is where plastic is made.

Plastic comes as a by-product of oil refining, and uses only 4% of the total worlds oil production.

It is a 'biogeochemical' manipulation of certain properties of oil, into polymers, that behave 'plastically.' Plastic polymers are manufactured into 5 main types, of which, plastic bags are made of the type known as Polyethylene. Raw Polyethylene comes from oil refineries as resin pellets, usually 3-5 mm diameter, by 2-3 mm tall. The raw material, as it is called, since it is plastic, can be manipulated into any shape, form, size, or color. It is water tight, and can be made UV resistant. Anything can be printed on it, and it can be reused.

Since plastic is so malleable, there are numerous processes used to turn plastic into finished goods. To make bags, a machine heats the Polyethylene to about 340 F and extrudes, or pulls out from it, a long, very thin, tube of cooling plastic. This tube has a hot bar dropped on it at intervals however long the desired bag is to be, melting a line. Each melt line becomes the bottom of one bag, and the top of another. The sections, then, are merely cut out, and a hole that is to be used as the bags' handle is stamped in each piece. Further finishing may be done such as, screen printing, however, for the majority of bags, it's off to the stores, etc., where they will be used.

With the exception of large, fuel burning, heavy machinery, used in the acquisition of oil, the entire plastic bag making process uses only electricity. The electricity used from start to resin/raw material is mostly nuclear. The power used in the bag manufacturing, for the most part, comes from coal fire power plants. One interesting note is that approximately 50% of the electricity generated from coal burning power plants is not from coal at all, it is, in fact, wrought from the burning of old tires, they being made of rubber, which is plastic.

Where it goes to: Paper.

When paper is thrown away, it can go to one of two places: The landfill or the recycling center. If it goes to the landfill, it will decay in time. If it is recycled, the paper will go through a lengthy process of disintegration and renewal.

When paper first reaches the recycling center, it must be returned to the state of pulp by using many different chemicals, such as sodium hydroxide, hydrogen peroxide, and sodium silicate.

These chemicals will bleach and disperse the pulp fibers. The fibers are then run through cleaning and screening sequences which remove any contaminants. The pulp must then be washed with clean water to remove ink particles that were removed from the paper by the chemical process.

Flotation is a widely-used method of removing the ink. The pulp is submerged in water, and heated. The ink attaches to air bubbles, which must then be removed before they break and let the ink float back to the pulp. This is a tedious process, involving a watchful eye and careful timing.

Most recycling centers will treat the water they used, and remove any contaminants. Screens and mechanical cleaners are the most common, which may let chemicals slip through. Another clean-up treatment that these centers will use is called "sludge handling". Sludge is composed of water, inks, pigments and small particles of waste. The materials are separated and cleaned. By including this process, it reduces any waste that may have to be taken to the landfill. These materials can be used in bricks and fertilizers as well as other useful products.

Where it goes to: Plastic.

Like paper, when plastic has been used, it can go to one of two places: The landfill or the recycling center. In a landfill, plastics make up 7% of the waste by weight, and 18% by volume. Of the 44,100 million pounds of plastic products made each year, 26,700 million pounds ends up as municipal solid waste.

As landfill useage decreases each year, it is becoming more popular to incinerate our garbage. Today, with the requirement of emission controls on smoke stacks, burning garbage is 99.9% cleaner than in days of yore. About 10% of all garbage is burned, of this, plastic makes up, as previously stated, 18%.

One of plastics greatest assets is its recycleability. To recycle almost any kind of plastic is to mearely re-melt, and re-form. The re-melting will sterilize, allowing any recycled plastic to be used in even hospital grade products. And plastic can be re-formed into anything, many times over before it becomes brittle, whence it can be made into an ashtry or a mouse pad. If society were to implement a strict plastic recycling, an enormous percentage of plastic would efficiently be used, again.

Evidence #3: The success of the plastic bag has meant a dramatic increase in the amount of sacks found floating in the oceans where they choke, strangle, and starve wildlife.

Impact: Paper.

The recycling of paper is essential in cutting down on landfills: each day, enough paper is recycled to fill a fifteen-mile long train of boxcars. When this statistic was taken in 1993, only 40 percent of paper used was being recycled. That left a lot that was thrown into landfills. By the year 2000, it is estimated that 78 percent of all paper used in the United States will be recycled, as well as 15 percent of all paper overseas.

Buying recycled paper is usually more expensive than buying virgin paper products, but the government, in an attempt to encourage recycling, presented purchasing mandates that can allow a 10 to 15 percent price premium so that it can compete with other cheaper paper products.

Another factor to consider is water pollution. The making of paper, whether virgin or recycled, uses many thousands of gallons of clean water that can soon become polluted in the papermaking process. Virgin paper creates 35 percent more water pollution than recycled paper. Recycled paper also creates 74 percent less air pollution than virgin paper. However, both types of paper can contribute to contaminating area waters. Scientific evidence shows that fish can experience adverse effects through chemicals that reside in sediment. It can more than three years for any level of toxicity to lower.

Impact: Plastic.

Plastic impacts in two ways: First, it hits the environment in its use of electricity when being manufactured. More than half of the power needed to make plastic bags is generated by nuclear fission. While controversial, it is argued that nuclear power puts no direct harm or detriment into the environment. The only drawback to nuclear power is the radioactive waste, which is, so far, being safely disposed of in deep underground caves. And, in deep sea trenches where the nuclear waste is subducted into earth's mantle and incinerated.

Pertaining to the rest of the electricity needed to make plastic bags, coal fire does pollute. But, plastic can be burned. In fact, the burning of plastic will yield from 10,000 to 20,000 btu per pound, of which 60% can be recovered. As stated above, plastic is burned to create electricity, hence, we could use plastic to make plastic, and reduce sulphur emissions from coal.

There is the question, though, of recovery of energy by burning plastic. This, too, causes controversy but only because of mental block. If 93% of all oil is burned straight away, why can't the 4% used as plastic have a second life as energy? The burning of plastics isn't without its drawbacks. Inks and additives to some plastics can create dioxins, and emit heavy metals when burned. Also, after being burned, the toxic ash still needs to be disposed of in toxic waste dumps.

Another problem with the incineration of plastic is the argument that the energy produced by the process doesn't justify the misuse of a limited natural resource. The plastics already produced are better utilized by making new plastic materials by recycling.

The second way plastic impacts is through landfills. Plastic will never break down; It will never disappear. Biodegradable plastic is a misnomer because wood fiber has been mixed with the plastic so when buried, the wood dissolves leaving a million tiny pieces of plastic, instead of one bag. As stated, plastics make up 18% of waste by volume, and 7% by weight. If plastic were to be replaced in its uses by other materials, rubbish weight would increase by 150%, packaging would weigh 300% more, and energy consumed by the industry would increase by 100%. It has been found that the reduced weight of plastic has spillover benefits, elsewhere. Reduction of weight in aircraft saves an average of 10,000 gallons of fuel per plane, per annum, world over. In automobiles, it is directly responsible for doubling the fuel efficiency since the 1970's. Applied to plastic bags, they reduce weight in landfills; They take up less space. This being in light of the discovery that most landfills are air tight, not allowing decomposition, leaving readable newspapers and chicken bones with meat still on them.

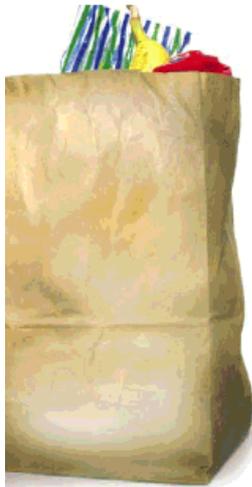
Conclusion

The making of paper can waste many thousands of gallons of water, as can the recycling of paper. The human and mechanical efforts and costs are very high, not forgetting the physical cost to loggers and those who work around the numerous chemicals. Plastic is, by comparison, efficient and low energy to produce, and, easily and efficiently recycled. Plastic reduces, recycles marvelously, and in that, is reused. After contrasting the efforts behind the making of paper and plastic, it is our unbiased opinion that plastic is indeed more beneficial to the environment, in that it is less harmful. The next time you are asked the dreaded question, "Paper or plastic?", you can answer knowing that you are making the informed choice.

Sources

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Evidence #4: Many do not know that it takes as many as 4 times as much energy to manufacture a paper bag.



MORE THAN MEETS THE EYE

An occasional feature that digs deeper into things you've been wondering about

Paper or Plastic?



We hear the question almost every time we go grocery shopping. Some shoppers answer automatically: plastic — convinced that they are making a better choice for the environment. Others ask for paper, believing the very same thing. The reality is that both paper and plastic bags gobble up natural resources and cause significant pollution. When you weigh all the costs to the environment, **you might just choose to reuse:**

PAPER

CONSUMPTION Americans consume more than **10 billion paper bags** each year. Some **14 million trees** are cut down annually for paper bag production.

Four out of five grocery bags in this country are plastic. The U.S. uses 100 billion plastic bags annually, made from an estimated 12 million barrels of oil.

PLASTIC

Worldwide, an estimated 4 billion plastic bags end up as litter each year. Tied end to end, **the bags could circle the Earth 63 times.**

PRODUCTION Paper, of course, comes from trees. Trees are grown or found, then marked and felled.

1. Logs are moved from the forest to a mill, where there is a three-year wait for the logs to dry before they can be used.
2. Logs are stripped of bark and chipped into one-inch squares. The chips are "cooked" with tremendous heat and pressure.
3. Then, they are "digested" with limestone and sulfurous acid until the wood becomes pulp.
4. The pulp is washed, requiring thousands of gallons of fresh water and bleach, then pressed into finished paper.
5. Cutting, printing, packaging and shipping to make paper bags require additional time, labor and energy.

It takes more than four times as much energy to manufacture a paper bag as it does a plastic bag.

Energy to produce bags:

Plastic **594 BTUs***

Paper **2,511 BTUs**

7 in 10 Americans do not know that plastic is made from petroleum products, primarily oil, according to a recent nationwide online survey.

* BTU = British thermal unit

Plastic is a by-product of oil refining. Plastic bags are made from polyethylene, which comes from oil refineries as small resin pellets.

1. A machine heats the pellet to about 340 degrees and pulls out from it a long, thin tube of cooling plastic.
2. A hot bar is dropped on the tube at intervals, melting a line.
3. Each melted line becomes the bottom of one bag and the top of another.
4. The sections are cut out and a hole for the bag's handles is stamped in each piece.

POLLUTION

The use of toxic chemicals during the production of paper for bags contributes to air pollution, such as acid rain, and water pollution.

The production of paper bags generates 70 percent more air and 50 times more water pollutants than production of plastic bags.

Air pollutants



Water pollutants



Plastics production requires toxic chemicals. In an EPA ranking of chemicals that generate the most hazardous waste, five of the top six were commonly used by the plastics industry.

Hundreds of thousands of marine mammals die every year after eating discarded plastic bags. Turtles think the bags are jellyfish, their primary food source. Bags choke animals or block their intestines.

RECYCLING

Paper must be returned to pulp by using many chemicals to bleach and disperse the fibers. Although paper bags have a higher recycling rate than plastic, each new paper grocery bag you use is made from mostly virgin pulp for better strength and elasticity. Bags that are recycled are often turned into corrugated cardboard, not new paper bags.

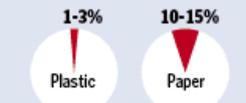
It takes 98% less energy to recycle a pound of plastic than it takes to recycle a pound of paper.

Energy used to recycle bags:



But recycling rates of both types of bags are extremely low.

Percentage of bags recycled:

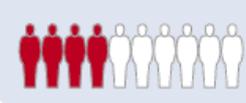


Recycling almost any kind of plastic involves remelting and re-forming it. Because bags must first be separated by the type of plastic they were made from, the process is time-consuming and expensive. For example, it can cost \$4,000 to process and recycle 1 ton of plastic bags. This can then be sold on the commodities market for about \$32. More often than not, bags collected for recycling never get recycled. A growing trend is to ship them to countries such as India and China, where they are cheaply incinerated under more lax environmental laws.

BIODEGRADABLE?

Paper is degradable, but it cannot completely break down in modern landfills because of the lack of water, light, oxygen and other necessary elements. About 95 percent of garbage is buried beneath layers of soil that make it difficult for air and sunlight to reach it.

Even though petroleum-based plastic will never biodegrade, nearly 4 in 10 believe plastic will biodegrade underground, in landfills or in the ocean.



Petroleum-based plastics are not biodegradable, meaning they will not decompose over time. But they do take up less space than paper in a landfill: 2,000 plastic bags weigh 30 pounds; 2,000 paper bags weigh 280 pounds.

WHAT YOU CAN DO



◀ **Invest in high-quality reusable bags**, each of which has the potential to eliminate an average of 1,000 plastic bags over its lifetime. The bag will pay for itself if your grocery store offers a 5- or 10-cent credit per bag.

▶ **Buy collapsible plastic crates** ▶ and keep them in your car. At checkout, food goes into the crates, making it easy to bring food into the house in one or two trips.

▶ **No bag at all?** Think twice about requesting a plastic bag if your purchase is small and easy to carry.

▶ **Reuse the bags you have.** Line your litter box with them; crumple them and use them for packing; cut the handles off, add some string and make a toy parachute; use them for an impromptu diaper pail; line your trash cans with them; be creative.

▶ **Keep reusable bags in your home, office or car** so they are available when you go shopping.