Feeding the People

1. a. Make a list of agricultural technologies that may allow us to produce more food. Make a chart with the labels ‘technology’ and ‘how it improves food production’. (You must have three different technologies). \*\*Create the list from your own knowledge!
2. Which of the technologies in your chart have created environmental problems? Describe how the technology has caused the environmental problem.
3. What change in diet would allow a growing human population to be supported without any further increase in farmland? Explain your answer.
4. Why are monocultures more susceptible to pest infestations than natural ecosystems?
5. Each new agricultural technology increases the amount of food that can be produced. As each technology is applied, it permits a larger population of people, ad the populations grow. Next another technology is developed and introduced increasing food and then populations. It is not likely that this cycle can be maintained indefinitely. Many ecologists are forecasting a disaster for ecosystems and a wave of human misery when the cycle fails and the carrying capacity of the planet is exceeded.
6. Is it possible to break the cycle? Offer some suggestions, explaining how they could be implemented.
7. Is the carrying capacity of our planet solely dependent upon food production? What other factors could limit carrying capacity?
8. Define pesticide, first generation and second generation pesticide. List three possible short-term benefits of using pesticides.
9. Why might chemicals taken form plants create a much lower risk for humans and ecosystems?
10. How would a chart showing the concentration of toxins differ from a biological pyramid of biomasss for the same food chain. Explain.
11. Vultures and some other species of beetles feed on the dead bodies of animals from several trophic levels. Predict how these animals might be affected by biomagnification.
12. Why is the fact that other countries have not banned DDT of concern to Canadians?
13. Breast milk contains fat. Speculate about how breast-feeding might affect the concentration of DDT in a mother and in her baby.
14. Why are the new pesticides less harmful to ecosystems than DDT and related compounds used in the 1950’s and 1960’s?
15. It is often said that technology can work as a double-edged sword, creating a new problems as it solves an old one. The new problem often arises because the solution to the original problem was flawed.
16. During the 15th century, arsenic, lead and mercury were applied to crops as insecticides. What was wrong with this technological solution?
17. In 1939 Paul Mueller found that DDT was a potent insecticide and could be used to kill pests such as mosquitoes. What was wrong with the technological solution?
18. Modern insecticides are easily broken down in the body and the soil and do not accumulate in fat tissues, however, these new chemicals do not provide a perfect solution. What dangers were created by this most recent technological solution?

Agriculture and Food Production

→ More than 6 billion people inhabit the 145 billion km2 of land on planet Earth.

→ Estimates indicate the population will likely soar to nearly 10 billion by 2050. The most dramatic increase will occur in areas that are already crowded.

* Only about 11% of the land is suitable for growing crops, most experts believe that new technologies are unlikely to increase the percentages.

Watering the Desert

Dry pasture land, normally used for raising cattle, sheep or goats could be modified to grow crops. Adding water to an arid landscape can have dramatic effects. Near deserts can support rich plant growth, if all necessary conditions are met.

This technological solution has two requirements: an abundant source of water (which must be diverted or pumped from somewhere else); and an irrigation system. Depending on the size the project and the geological conditions, these two requirements may be fairly easily achieved, resulting in a new productive cropland. However, large projects on challenging terrain would be very expensive, and may produce food at a price too high for most people to afford.

All freshwater contains a small amount of salts during the heat of the day some of the water being used for irrigation will evaporate from the soil but the salt remains. Each day the flow of water brings more salt. As the concentration of salts rises, the soil eventually becomes too salty grow crops.

Fertilizing the Soil

If we can not increase the amount of land used for crops, we must explore other approaches. The use of nitrogen, phosphorus and potassium fertilizers dramatically increased to the production during the 1960’s and 1970’s. Before the widespread use of fertilizers farmers had to rotate crops to ensure that nutrients were replenished, for example using a legume crops to restore nitrogen to a field that has been deleted by growing grains.

As with irrigation, the technological fix offered by spreading fertilizers on land is not without risk. The nutrients seep into groundwater, runoff into surface water, stimulating the growth of algae in lakes and rivers. Eventually the algae die and are decomposed by bacteria to return the nutrients to the water. However, the bacteria also used up the oxygen in the water. With less oxygen, fish and other organisms begin to die.

The Threat of Monocultures

Any discussion about increasing food production for humans must take into account the damage done to the ecosystem by agriculture and forestry. Attempts to produce more food or harvest more timber have involved replacing biodiverse ecosystems with artificial ecosystems that contain a single crop, a single source of food.

Environmental damage might occur on any scale. For example, to create more space for crops, a farmer might drain a marsh or remove a small strand of trees. Additional planting space means increases crop yield. However by draining the marsh or removing the trees, the farmer is reducing the biodiversity of the land.

A wheat field is a monoculture, an ecosystem in which there is only one plant. It is designed to produce a single food The amount of fertilizer applied, irrigation, and the timing of harvesting can all be adjusted to make conditions in the field as close to ideal as possible for a single crop. Other species that have different nutritional requirements or needs for water can be ignored. In addition, many species that interfere with the growing and harvesting of the crops are removed. Unlike diverse natural habitats, monocultures tend to support very high populations of a limited number of species. But monocultures are especially vulnerable to pests. In a grain field or managed forest, the pest lives in an artificial ecosystem that may not contain many of its natural predators.

There is also a vast supply of food for the pest. The eggs of pests hatch amid a food supply that could support a huge population, if the farmer would allow it. In addition, the food attracts and supports many members of the same species from surrounding areas. A rapid rise in population is likely when animals don't have to expend much time and energy looking for food and mates. In a monoculture, pests have lots of free time and energy, and few predators to contend with. Monocultures are incubators for a few species of organisms.

Pesticides

Pesticides -- are chemicals designed to kill pests. A pest is an organism that people consider harmful or inconvenient, such as weeds, insects fungi and rodents.

**Why use pesticides**! One estimate suggest that as much as 30 percent of the annual crop in Canada is lost to pests such as the rust, moulds, (both forms of fungi), insects, birds and small mammals. The cost to consumers can be staggering. For example in 1954 three million tons of wheat from the Prairies was destroyed by stem rust a fungus that grows inside the leaves and stems of the wheat plant, feeding on the plant's stores of food.

First generation pesticides -Our attempts to control pests extend back to about 500 BCE, when sulfur was first used to repel insects. During the 15th century Arsenic, Lead, and Mercury were applied to crops as insecticides. As many farmers eventually discovered, the substances were not only deadly for insects, but also highly poisonous for people. By the 1920s farmers have become fully aware of the hazardous effects and practice was abandoned. Unfortunately, these dangerous substances will show up in some vegetables if they are grown in soils that were treated with the metals for a great number of years.

In 1763, French gardeners began using nicotine sulfate, a chemical extract from the tobacco plant to kill agents By the 1800s two more plant extracts had been developed in the battle against insects, one from the bead of the chrysanthemum, and the other from the roots of a tropical legume. Many plants develop chemical defenses against animals Insects and other animals that try to eat the leaves or seeds die or become ill. They learn to avoid the plant in future. Borrowing those chemicals from plants seems to make sense.

Second Generation Pesticides - are chemicals made in a laboratory. In 1939 Paul Mueller found that dichlorodiphenyltrichloroethane (DDT) a chemical known since 1874 was a potent insecticide. This discovery forever changed the practice of chemical control. It sent researchers looking for more such

chemicals, which were developed to protect troops fighting in the tropical jungles of Asia and the Pacific during World War ll.

Thousands of pesticides have since been developed. More than 500 chemical pesticides are registered for use in Canada alone. Worldwide approximately 2.3 million tonnes of pesticides are used yearly or about 0.4 kg for every person on Earth. About 75% of these chemicals are used in developed countries, and they are not used only in agriculture. Pesticides are added to shampoos, carpets, mattresses, paints, and even on the wax on produce. More than 25% of pesticides are used to get rid of pests in homes, gardens, and parks.

Bioamplification or Biomagnification - Pesticides that contain chlorine, such as DDT are soluble in fat but in water. As a result, these toxins cannot be released in urine or sweat, so they accumulate in the fatty tissues of animals. When there is a small amount of the' pesticide in the environment, it will enter the bodies of animals that are low in the food chain.

Even though there is only a small amount of the toxin in each of the prey animals that a secondary consumer eats, the amount of the toxin in its body will be larger because each predator eats many prey. When the secondary consumer is eaten, the higher-level predator gets all of its toxins, plus those of all the other prey it eats. At each stage of the food chain the concentration becomes greater. The higher up the tropic level, the greater the concentration of toxins becomes.

Effects on Humans - Like other top predators, humans are subject to bioamplification. Evidence that DDT was beginning to accumulate in humans was collected in the 1950s andI960s. DDT levels became especially high in humans who lived where DDT was sprayed on crops. However, anyone who ate crops from these areas or ate animals that had fed on the crops was exposed to DDT. DDT was banned in Canada in 1971 and the US in 1972. The ban hasn't totally eliminated the problem. Migratory birds like the mallard duck, Canada goose, and peregrine falcon winter in Central America and Mexico, were DDT is still used. Fish living in the Atlantic and Pacific oceans also migrate up and down the coasts.

Modern Chemical Pesticides - Unlike DDT and other chlorine-based insecticides, the newer chemicals are not stored in fat tissue; they are soluble in water. Animals can remove them from their bodies by breaking them down in their livers and excreting them. They can also be broken down within the soil. These new compounds operate like nerve gases, which act by preventing electrical messages from traveling from the brain to the muscles that control breathing or the limbs. This either kills the animal directly or makes it vulnerable to predators.

Although somewhat safer than the older chemicals, the newer insecticides are not without their problems. First they break down quickly in the soil, and so must be reapplied to crops more often, second, these new chemicals are not selective. Since the nerve action of most larger animals is very similar, these insecticides are capable of killing mammals, birds, reptiles, amphibians and fish. Unintended changes to the food web are difficult to predict. Third, animals that have dies or been weakened by the toxin put any other animals that eats them at risk through biomagnification. Large dosages of the toxin can still cause death.

Pests Fight Back - Chemical pesticides seem to have a natural shelf life, because the pests they are supposed to kill gradually become resistant. This is particularly true of bactericides and insecticides, because of the pests' high rates of reproduction.

How does it work? If the first application of a chemical kills 90% of the insects the 10% that survive have genes that helped them survive application of the pesticide. With every generation of insects, the pesticide removes those that are susceptible, and leaves those that are not. In addition, because the pesticide removes so many of the insects, the survivors have the benefit of less competition for food. After several generations of this selection process, most of the insects carry genes that will help them survive an application of the pesticide. Eventually the pesticide becomes useless, and pesticide chemists must search for a new poison.

Integrated Pest Management - combines natural controls and cultural practices with limited use to pesticides. Examples of integrated pest management range from simple practices, such as building bird - houses that attract insect-eating birds, too much more complicated strategies involving the use of predators, parasites, and competition for food supplies. The objective is to learn as much as possible about the biology of the pest organism, and use the knowledge to reduce its population.

One effective example of integrated pest management comes from China. Instead of spraying insecticides, farmers have begun building straw huts in the rice fields during the fall. The huts provide shelter for spiders looking for a place to hibernate. More spiders survive the winter, and when spring arrives they emerge with a ravenous appetite for the insect pests that live on the rice. The estimated 30,000 species of spiders in the world kill more insects yearly than do all the worldwide insecticide applications. The typical meadow can contain as many as 2 million spiders, each devouring hundreds of insects annually.

The biggest advantage to integrated pest management is that it allows the farmer to focus on the target species, and reduces the damage to other species in the ecosystem. In Canada and the United States, spiders have been used to control spruce budworm an insect that infects and kills spruce and fir trees. Spiders have also been used to controlled gypsy moths, which feed on the leaves of trees such as popular and birch. In warmer climates, banana spiders have been used to control cockroaches.

In Newfoundland, plastic mulches on cabbage and celery have reduced the need for weed – killing herbicides. In New Brunswick, potato growers are using a monitoring system for aphids; by treating aphids .at the most vulnerable time, they can use a smaller dose of pesticides. In Nova Scotia, predator mites are being used in apple groves and strawberry farms to control pests. In Prince Edward Island, pests that eat the leaves of broccoli, cauliflower, and potato plants have been studied to determine action thresholds (situations in which pest numbers reach a critical point, resulting in the need for action). Knowing when to act and when to let the ecosystem use its natural regulatory mechanisms actually may be the most important factor in integrated past management.

Other Weapons Against Pests

Another important weapon for the farmer is crop rotation, a practice that has been used less often since the invention of modem chemical fertilizers. Changing the plant in the monoculture reduces opportunities for pests. The pest larvae will emerge to discover a food supply that is not only different from the one their parents fed on but also possibly unfavourable. In addition, the new vegetation may attract different predators.

Planting times can sometimes be adjusted, so that when the insect pest emerges there are no growing plants to feed on. In Nicaragua, small patches of cotton are planted ahead of the main crops. After the parasitic boll weevil hatches, it must move to these small patches to find food. The small planting is a trap: once the weevil enters the trap crop, it can be destroyed by hand or by reduced amounts of pesticide. By the time the main crop begins to grow, the population of pests has already been much reduced. Removing sick or infected plants can forestall a pest epidemic. Diseased plants, which are weaker and do not have their normal defenses, can act as incubators for pests.

Microbes and Biological Control

One of the most successful biological controls in Canada is the bacterium Bacillus thurigiensis, commonly known as Bt. This microbe produces a protein that is highly toxic to caterpillars, including those of the spruce budworm. Other strains of the microbe have proven effective in the control of the Colorado potato beetle. Concerns about the impact of Bt on food webs have been raised by the Natural History Society of PEI., where Bt is being used to control biting flies. The Environmental Protection Service and Canadian Wildlife Service are monitoring the P .E.I. program to determine its impact on aquatic ecosystems.