1) There is Too Much Carbon Dioxide in our Atmosphere
   a) Science guys say we need to reduce CO2 emissions by 80% worldwide, more than 90% here, in order to reduce probability of catastrophe, ie end of life as we know it.
   b) basic problem is this:
      i) more CO2 in the atmosphere makes the surface temperature of Earth higher (think Venus)
      ii) much CO2 flows in and out of the atmosphere on a pretty short clock: ie, annual plants suck up CO2 while they live, but then a year later, they die and decompose and release their CO2 back into the atmosphere; a big old tree sucks in CO2 for a thousand years, and then puts it back when it dies.
      iii) dinosaurs and other big creatures roamed the earth for about 100 million years leading up to 65 million years ago. *Some* of these guys died and were buried, and then turned into CO2-rich oil, coal and natural gas. Now, we are pulling this stuff up, burning it and returning the CO2 to the atmosphere.
      iv) the problem is that we have pulled up and burned, say, 1/3 of the buried stuff and burned it in 100 years. That is, in 100 years, we have returned to the atmosphere the CO2 that took 33 million years to sequester: we are putting it back at 333,000 times the rate it was extracted.
   c) Summarize Scientific American Article:
      i) human-induced warming over the past three and a half decades has had a discernible influence on physical and biological systems
      ii) The key driver of climatic change is greenhouse gas emissions from human activities
      iii) The report of the Intergovernmental Panel on Climate Change places the probability that global warming has been caused by human activities at greater than 90 percent.
      iv) the future, particularly in the longer term, remains largely in our hands--the magnitude of expected change depends on what humans choose to do about greenhouse gas emissions.
      v) The atmospheric concentrations of carbon dioxide, methane and nitrous oxide remained roughly stable for nearly 10,000 years, before the abrupt and rapidly accelerating increases of the past 200 years. Growth rates for concentrations of carbon dioxide have been faster in the past 10 years than over any 10-year period since continuous atmospheric monitoring began in the 1950s, with concentrations now roughly 35 percent above preindustrial levels
      vi) the earth is being pulled to a warmer climate and will be pulled increasingly in this direction as the "anchorman" of greenhouse warming continues to grow stronger and stronger.
      vii) trend over 1906 to 2005 is now 0.74 ± 0.18 degree C. Note that the 1956 to 2005 trend alone is 0.65 ± 0.15 degree C

viii) Since 1993 satellite observations have permitted more precise calculations of global sea level rise, now estimated to be 3.1 ± 0.7 millimeters per year over the period 1993 to 2003

ix) apparent mismatch between the instrumental surface temperature record (which showed significant warming over recent decades, consistent with a human impact) and the balloon and satellite atmospheric records (which showed little of the expected warming). Several new studies of the satellite and balloon data have now largely resolved this discrepancy--with consistent warming found at the surface and in the atmosphere.

x) Two patterns provide a fingerprint of human influence.
   (1) The first is greater warming over land than ocean and greater warming at the surface of the sea than in the deeper layers
   (2) second pattern of change is that while the troposphere (the lower region of the atmosphere) has warmed, the stratosphere, just above it, has cooled.

xi) The simulations suggest that, for greenhouse gas emissions at or above current rates, changes in climate will very likely be larger than the changes already observed during the 20th century

xii) the warmth of the past half a century is unusual in at least the previous 1,300 years. The warmest period between A.D. 700 and 1950 was probably A.D. 950 to 1100, which was several tenths of a degree C cooler than the average temperature since 1980.

xiii) over the next 20 years, for a range of plausible emissions, the global temperature will increase at an average rate of about 0.2 degree C per decade, close to the observed rate over the past 30 years. About half of this near-term warming represents a "commitment" to future climate change arising from the inertia of the climate system response to current atmospheric concentrations of greenhouse gases.

xiv) The best estimates of the increase in global temperatures range from 1.8 to 4.0 degrees C for the various emission scenarios, with higher emissions leading to higher temperatures.

xv) The simulations also suggest that the removal of excess carbon dioxide from the atmosphere by natural processes on land and in the ocean will become less efficient as the planet warms.

xvi) the estimates of the rise in sea level during the 21st century range from about 30 to 40 centimeters

d) Some Economists: we discount the future all the time---why is this any different? These bad things happen way off in the future, like a century from now.

e) Other Economists: the right discount rate when dealing with people that we can't make deals with is nearly zero.
f) Ethics guys: why should we sacrifice so that our (richer than us) descendants are better off?
g) Other Ethics guys: their well-being should be valued just as much as our own, even though they aren't born to talk to yet. Not being born yet should not bear on their ethical importance.

2) If this is undesirable, why did it happen in free markets? After all, the first fundamental theorem tells us that in simple markets, voluntary trade gets us efficiency.
   a) If markets are not simple, due to a *market failure*, then you don't get efficiency.
   b) Here, the market failure is an *externality*.

3) Externalities
   a) Externalities are effects that one agent has on another that are external to the market.
      i) Of course, we affect one another when we trade: i get something from you, you give it to me, i give you money for it. However, this stuff is internal to the market.
      ii) What if i get something from you, you give it to me, i give you money, and in the process, some 3rd party is injured. This latter effect was external to the market that connects you and me, and is thus an externality.
   b) They can be positive or negative.
      i) Classic negative externality is pollution.
      ii) I buy gas from the gas station (marketed), and drive to work, poisoning residents of the Fraser Valley (externality).
      iii) Classic positive externality is literacy.
      iv) If you are literate, you raise the productivity of everyone around you. But, they don't pay you to be literate.
      v) Another positive externality is a nice front yard.
   c) We may think of externalities as **missing markets**.
      i) If there were a market for the effect under consideration, then there is no externality.
      ii) Missing market is the lack of a market for pollution reduction that residents of Abbotsford can buy which would curtail my driving.
      iii) Missing market for neighbours paying each other to have nice gardens.
      iv) You can use the missing market to imagine the pareto improvement that might be available, and consequently to see exactly why the situation with the externality is inefficient.
      v) Pareto improvement: Abbotsfordois each pay each Vancouver driver $10 to drive 10% less.
         (1) we know that the Vancouverites are driving to much, because they don't pay any attention to the health of the Abbotfordois.

4) Prices
   a) Why can we speak of 'a' price for a good? Couldn't there be many prices for a good?

i) The buyers would all want the lowest price, and the sellers would all want the highest price.
ii) If buyers and sellers can choose who they trade with, they'll choose the ones that are best for them.
iii) The sellers will choose the buyer with the highest price (willingness to pay); the buyers will choose the seller with the lowest price.
iv) Only buyers who match the highest-paying buyers' price will be able to trade; only sellers who match the lowest-charging seller's price will be able to trade.

b) One of the conditions of the first fundamental theorem is that no player has any power on the price. This condition is actually what allows us to have 'a' price (rather than many prices) for a particular good.

c) The price conveys information
i) Since trade is voluntary, the transaction price conveys a lower bound on the 'worth' of the good to each and every person who bought it. Also, since each buyer is allowed to choose how much to buy, the transaction price conveys the exact 'worth' to each buyer of the last unit that s/he bought.
ii) Likewise, since trade is voluntary, the transaction price conveys an upper bound on the cost (to create or to sacrifice) the good to each and every person who sold it. Also, since each seller is allowed to choose how much to sell the transaction price conveys the exact cost to each seller of the last unit that s/he sold.
iii) Given the conditions for the first theorem, the market price thus equates the value to the buyer with the cost to the seller of the last good bought or sold by each buyer or seller.
iv) This equality is what generates efficiency.
(1) if the equality does not hold, you get inefficiency. imagine that we had done some trade and that there was some buyer out there who felt that one more unit of the good would be 'worth' $5 to them, and that there was a seller out there who felt that one more unit of the good would cost them only $4. Then, there would be incentive to trade another unit: both parties would have something to gain, and an improvement is at hand.
(2) could you have the opposite, where a buyer feels that the last unit they bought was only worth $4, and there is a seller for whom it costs $5? Then, the gains from trade would be moving that good from buyer to the seller—they change identities.
v) Many inefficiencies can be thought of as situations where the market price is 'wrong' in some way.

d) **When there is an externality, the market price is 'wrong'.** The market price does not convey the exact costs or benefits, because it leaves some peoples' costs and benefits out.

e) With CO2, the market price of emission is zero almost everywhere in the world, but the CO2 imposes a cost on every resident of Earth in terms of higher temperatures, greater climate variance and higher sea levels.

5) Externality taxes

a) With a negative externality, the market price is too low.

b) One possibility is to introduce the missing market.
c) But, perhaps it was missing for a reason, eg too complicated to create.
d) The government can 'fake it' for us: tax the Vancouver drivers so that they drive less.
e) Who gets the revenue? From the point of view of efficiency, this doesn't matter. Depends on who owns the air: is air supposed to be clean or dirty. If it is supposed to be clean, then effectively, the abbotsfordois own it, and the Vancouverites must pay to dirty it. If it is supposed to be dirty, then effectively the Vancouverites own it, and the Abbotsfordois must pay them to keep it clean. **Either way, the price of driving goes up, and the amount of driving goes down.**
f) Government could impose a rule, like, 'don't drive', but imposing a tax is easier.

6) the *free-rider* problem: you can change your behaviour a whole lot, but if nobody else does, what good is your individual action? other people can "free-ride" on your good behaviour.
    i) free-rider problems are really common in our lives:
        (1) group projects for classes: if you work really hard, nobody else really has to---they can free ride on your work, so you end up with a weak project because nobody wants to work hard;
        (2) kitchen cleaning in a group-living situation---you end up with a dirty kitchen;
        (3) tax-evaders free ride on taxpayers.
    ii) free-riding is a generic problem whenever there is something consumed or used by everyone in a group, but where contributions to maintenance or quality or quantity are decided by the individuals in the group, and not by the group as a whole.
    iii) the result of free riding is that you get pressure towards too little good stuff, and too much bad stuff.
    iv) With CO2, we have a good---the atmosphere---used by everyone in the group---all living things---and contributions to maintenance---low CO2 emissions---are decided individually, and not by all living things (or even all humans) collectively. So, we get too much CO2. Given the evidence from the science guys, we get *way too much* CO2.

7) Tragedy of the Commons (Hardin, G. (1968). Tragedy of the Commons. Science, 162, 1243-1248.)
    a) here, a *commons* is a resource that is:
        i) jointly owned and used by a bunch of people;
        ii) **and** has the characteristic that nobody can be excluded from using it.
    b) the *tragedy of the commons* is that such resources get overused, because no individual has any incentive to preserve it.
    c) Hardin's example was of a common pasture, with people grazing their cows on it. Too many cows degrades (denudes) the pasture. But every individual has a strong incentive to put their cow on the pasture, because they get the whole benefit (a fed cow) and face only a tiny part of the cost (because their cow is one among many).

d) Hardin also uses an example much closer-to-home: fish stocks. Consider a river (like the Fraser) with tons of salmon. What happens when lots of seine boats float at the end of it scooping up fish for a few decades? No fish after a while.
e) The atmosphere is a commons. We all own and use it, but you can't exclude anyone from the atmosphere (except in Total Recall).
f) Each individual gets the benefit of polluting the atmosphere with CO2 (eg, cheap dirty energy vs expensive clean energy), but only faces a miniscule portion (ie., 1/6 billionth) of the cost of their emissions.
g) End result: way to much CO2 pumped into the atmosphere.

8) Individual action
   a) reduce your own CO2 footprint
   b) complex:
      i) everything you do has a CO2 footprint
      ii) you don't want to reduce to zero: that is going too far
      iii) so, how do you decide how much of each good to consume, ie, goods that come in plastic bags vs paper bags, goods that are made of metals vs plastics?
      iv) complexity in the individual decision hinges on the fact that things we consume are made of multiple inputs, each with an associated CO2 footprint.
   c) agitate for social change, but of what form?
      i) changes in individual beliefs and norms, like the anti-littering campaigns of the 1970s.
      ii) changes in government policy.
9) Government policy
   a) governments do lots of stuff, like tax and subsidize things, and regulate activity.
   b) taxation is pretty simple: government collects money as things are bought and sold, or as activities are undertaken.
      i) when labour is bought and sold, government collects income taxes.
      ii) when cigarettes are produced, the manufacturer pays a tax to the provincial government; when trees are cut down, the firm pays a tax to the province of BC.
      iii) when you tax an activity, you discourage doing it, and less of it gets done.
      iv) some activities are subsidized: their is (currently) a subsidy for investing in oil and gas exploration.
      v) when activities are subsidized, you encourage doing it, and more it gets done.
      vi) So, taxes and subsidies can change behaviour.
   c) Sometimes, we change behaviour by imposing rules.
      i) it is illegal to smoke within 5 meters of a public building.
      ii) adults must accompany children at the swimming pool.
      iii) these rules change behaviour, but typically in a zero-one yes-no kind of way.

10) Carbon Pricing
    a) put a price on the emission of CO2,
        i) by firms that emit CO2 when they produce goods.
        ii) by people that emit CO2 when they burn fossil fuels.
    b) putting a positive price on emission will reduce emission
    c) there are lots of ways to get a price on emissions, but they all involve the coercive power of government:
        i) *Carbon Taxes*: tax emissions at the point of production or the point of sale. the carbon price is the level of the tax.
        ii) *Cap and Trade*: create coupons which are necessary to emit CO2. Sell them (or auction them, or give them away) up to a certain cap (or limit) and allow people to trade them. The carbon price is the market price of the coupon.
        iii) *Regulate Emitters*: force emitters to decrease emission using the mighty fist of the state. emitters will comply, but their costs will be driven upwards. everything they sell will increase in price. the carbon price is the price increase.
11) If putting a price on carbon is so important, why can't the international community take care of it?
    a) The appropriate level of government to tax something that imposes costs on people is a level high enough to cover all the people affected.
        i) If you are taxing water pollution in lakes, you could use provincial governments: they deal with everyone involved: lake users, lake polluters.
        ii) but, *everyone on Earth* is affected by CO2 emissions, because everyone is protected by the same atmosphere. Thus, the appropriate level of government is the world.
        iii) Alas, there is no world government.
    b) here, the individual decision-makers are countries, and the group is the group of all countries. a country (or province!) that chooses to limit CO2 emissions risks all other countries free-riding on their efforts. so, the free-rider problem makes it very difficult to get all countries to agree to reduce CO2 emissions---every country wants to free-ride on every other country.
    c) The Kyoto Protocol was an attempt to get a large number of countries to reduce CO2 output together.
        i) Basically, every signatory agreed to reduce CO2 emissions from a (usually 1990) baseline to some lower level of output (usually 80-90% of those levels).
        ii) Countries were free to use whatever mechanisms they chose.
        iii) For a large number of signatories (many LDCs were not on-board with this bit), there was supposed to be a market to trade CO2 output across countries. Thus, if Canada wanted to produce more than its quota of CO2, it could buy quota from another country.
    d) Kyoto has mostly failed.
        i) World CO2 output has risen by more than half since 1990.
        ii) big countries like the USA, China and India didn't sign on.

iii) some signatories didn't do anything about it: Canada's CO2 output has risen by one-quarter.
iv) europe has been broadly successful in reducing emissions, though no european country has met is target.
v) arguments over CO2 credits have made it difficult to reach agreements: how should standing forests count? how should deforestation count?

12) Common misconceptions about carbon taxes (and all forms of carbon pricing)
a) taxing emissions won't reduce emissions enough
i) nobody says we want to use carbon taxes *exclusively*. you use it together with other kinds of social change
ii) if the current tax rate doesn't reduce emissions enough, raise the tax
b) taxing emissions will kill the economy
i) since you raise revenue from taxing emissions, you can decrease taxes on other things.
ii) So, now it comes down to the following problem: government needs revenue to provide public goods, so should it get it by taxing (and discouraging) things we like (such as work) or things we don't like (such as CO2 and other pollution).
iii) main point, if you impose carbon taxes, you can decrease income and other taxes.
iv) probably a wash, or a slight long-run help, for economic growth
c) taxing emissions will hurt the poor
i) poor people use CO2 intensive goods, like heating, and so they'd have to pay a lot of carbon tax.
ii) it is *very easy* to write poor people cheques: we do it all the time, through the GST credit, the Canada Child Tax Benefit, etc. So write them Carbon Tax Offset cheques, what's the big deal?
d) carbon tax revenue should be spent on carbon-related items.
i) imagine you get $5 from one friend and put it in your left back pocket and $5 from another friend and put it in your right back pocket. These are gifts. Now, imagine you go to the store to buy a bag of chips: which $5 bill should you use?
ii) Obviously, it doesn't matter.
iii) In the same way, the *source* of government revenue is not important in determining how to spend government revenue. If improving transit is important, then it is important whether or not we have a carbon tax, and we should spend money on it regardless of whether or not we have a carbon tax.
e) taxing emissions legitimates emissions.
i) If we set a price for emitting CO2, people will feel that it is 'okay' to emit as long as they pay the price.
ii) Wouldn't it be better to make emissions illegal, and by extension, immoral?

iii) This is hard to implement, hard to coordinate internationally, and unnecessary. If we really don't like CO2 emissions, then we should really tax them a lot.
iv) Thus, those who argue that carbon taxes legitimate carbon emissions could instead argue that what we need is a higher rate of carbon tax.

f) people will just try to avoid or evade carbon taxes
   i) Of course, people try to avoid taxes, and the higher the tax rates the more they try to avoid.
   ii) That doesn't make it right, but it does mean that carbon taxes might not be fully effective and would have to be accompanied by some form of monitoring and punishments for cheaters.

g) rich people won't change their behaviour---they'll still pollute like the dogs they are.
   i) Is it really fair to make low-income people do all the work here? We can take the sting out of the unfairness in just the same way we can take the sting out of the increase in the cost-of-living: by writing people cheques.
   ii) Think of this as rich people paying poor people to do the adjustment for them.

h) 'cap and trade' (selling coupons to polluters) is better than taxes since businesses, rather than consumers, pay.
   i) this difference is mostly illusory: businesses sell their stuff to people, and if their costs go up, the prices they charge go up.
   ii) Since the atmosphere doesn't care where greenhouse gases come from, we should probably put a price on all emissions, whether they come from businesses or from people.
   iii) we need carbon taxes for people and firms, or we could use a cap and trade (or carbon taxes) for businesses and a carbon tax for people.

i) regulation is better than taxing: you can just make big polluters pay fines. The problem is that we want little polluters to reduce their emissions, too. The atmosphere doesn't care whether or not the CO2 comes from big or little polluters---it just wants less of it.
   i) CO2 is not like speeding. when you drive superfast, you massively raise the probability of killing a bystander, so we want to discourage people from driving superfast. if you drive at a reasonable speed, the risks are tolerable.
   ii) in contrast the tailpipe emissions of CO2 from vehicles are roughly proportional the km's driven. thus you want to discourage all driving, not just speedy driving, or driving by people who drive a lot.

j) Canada is small. British Columbia is even smaller. Can we possibly have an effect on global greenhouse gas levels?
   i) Sadly, we cannot.
   ii) However, there is potential for Canadians to lead by example. We have not been doing this up to now---in fact, we have been doing the opposite (think tar sands).