A Method for "Point of Consumption" Attribution of Illness due to Food Commodities

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Why use outbreak data to attribute illness to various food commodities?

- **For most illnesses, the causative food can only be determined if the person was part of an outbreak**
- **Outbreaks capture information**
  - on both common and uncommon agents
 - on both common and uncommon food vehicles

eFORS (electronic Foodborne Outbreak Reporting System) is major data source

- ~1300 outbreaks reported each year from state and local health departments
- Using "frozen" dataset from 1998-2004
  - Developed software program for this dataset
    - Program does not work for later years because database was restructured
- 9,069 outbreaks reported from 1998-2004
  - 5,083 (56%) had agent determined, e.g., *E. coli*
    - 3,319 (65%) had specific food determined
      - 87,244 persons ill in these outbreaks

Categorized food items

- **Categorized >1,700 foods**
  - **listed the names of all the foods**
- **Accommodated many problems**
  - **e.g., duplicate names (lasagna and lasagne)**
- **Categorized the foods into commodities**

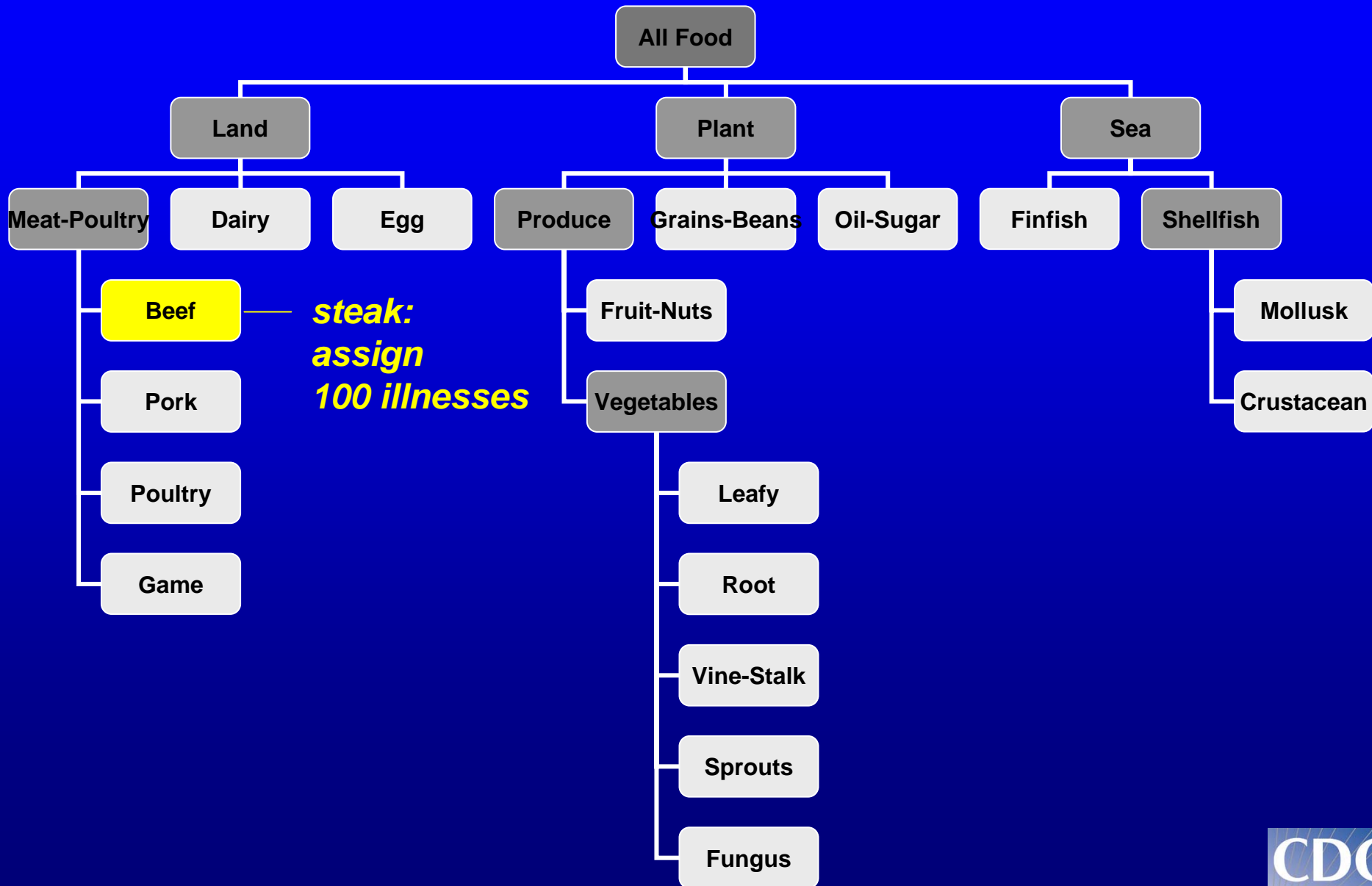# Hierarchical scheme for categorizing food items into commodities
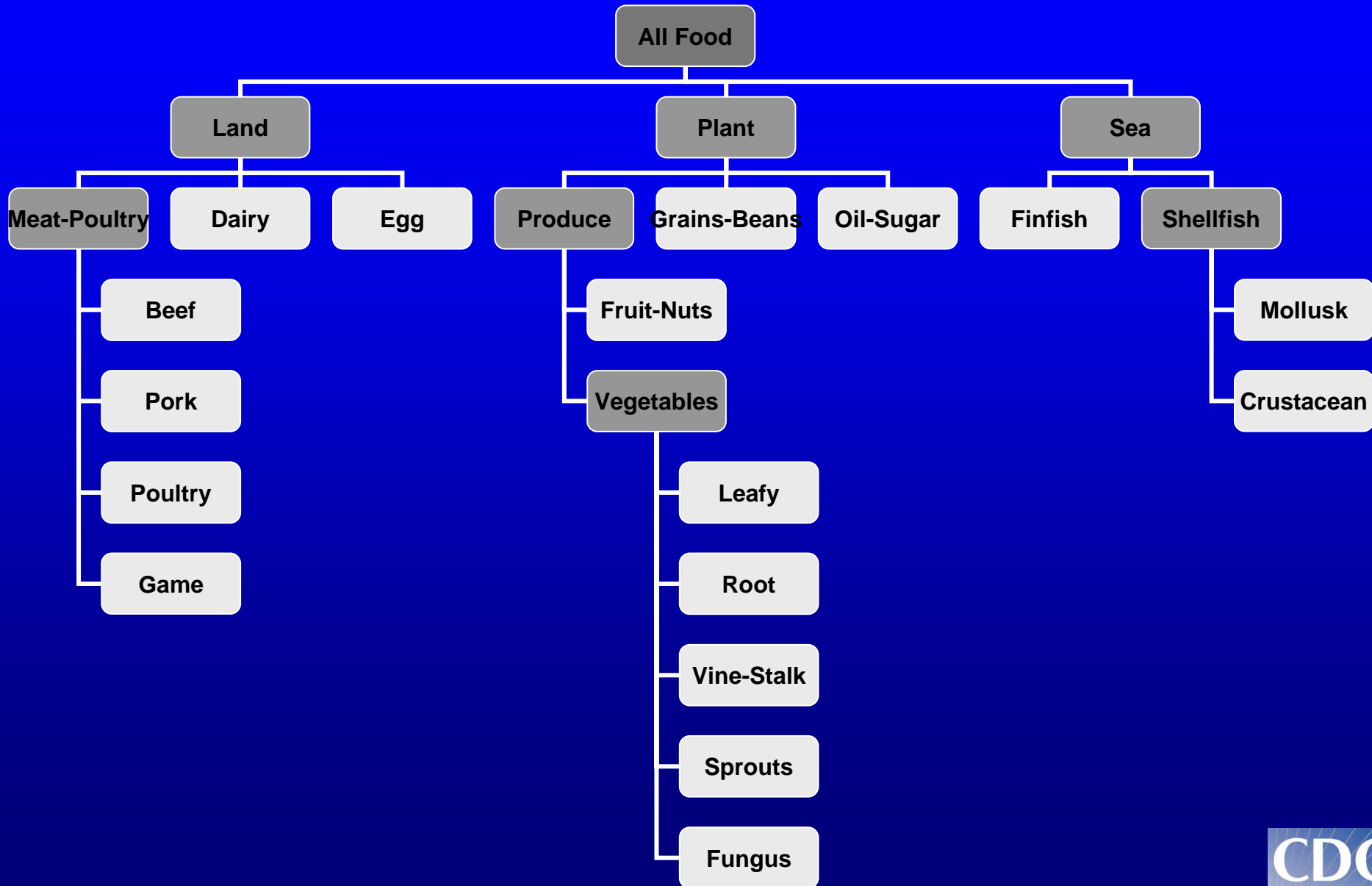
Simple and complex foods

- **Simple foods** contain only one commodity
- **Complex foods** contain more than one commodity

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Example of outbreak from simple food item (N=100 ill)

- Simple food item: steak
  - Commodity: beef

Simple food outbreak: steak

All Food

- Land
  - Meat-Poultry
    - Beef — *steak: assign 100 illnesses*
    - Pork
    - Poultry
    - Game
  - Dairy
  - Egg
- Plant
  - Produce
    - Fruit-Nuts
    - Vegetables
      - Leafy
      - Root
      - Vine-Stalk
      - Sprouts
      - Fungus
  - Grains-Beans
  - Oil-Sugar
- Sea
  - Finfish
  - Shellfish
    - Mollusk
    - Crustacean

Simple food outbreak: steak

```
                           All Food
                              |
         ┌────────────────────┼────────────────────┐
       Land                 Plant                  Sea
         |                    |                     |
  ┌──────┼──────┐      ┌──────┼──────┐        ┌─────┴─────┐
Meat-    Dairy  Egg  Produce Grains- Oil-   Finfish  Shellfish
Poultry                      Beans   Sugar
  |                    |                             |
  |                 Fruit-Nuts                    Mollusk
 Beef ── steak:         |                           |
  |      assign      Vegetables                  Crustacean
 Pork    100 illnesses   |
  |                    Leafy
 Poultry                |
  |                    Root
 Game                   |
                     Vine-Stalk
                        |
                     Sprouts
                        |
                     Fungus
```

Simple food outbreak: steak

All Food

Land — Plant — Sea

Land: Meat-Poultry, Dairy, Egg

Plant: Produce, Grains-Beans, Oil-Sugar

Sea: Finfish, Shellfish

Meat-Poultry: Beef, Pork, Poultry, Game

steak: assign 100 illnesses

Produce: Fruit-Nuts, Vegetables

Vegetables: Leafy, Root, Vine-Stalk, Sprouts, Fungus

Shellfish: Mollusk, Crustacean

Example of outbreak from complex food item:
hamburger sandwich causing *E. coli* outbreak, causative ingredient known (N=100 ill)

- Hamburger sandwich contains ground beef, lettuce, tomato, bun

  - If ground beef is the cause, can assign the illnesses to "Beef" commodity
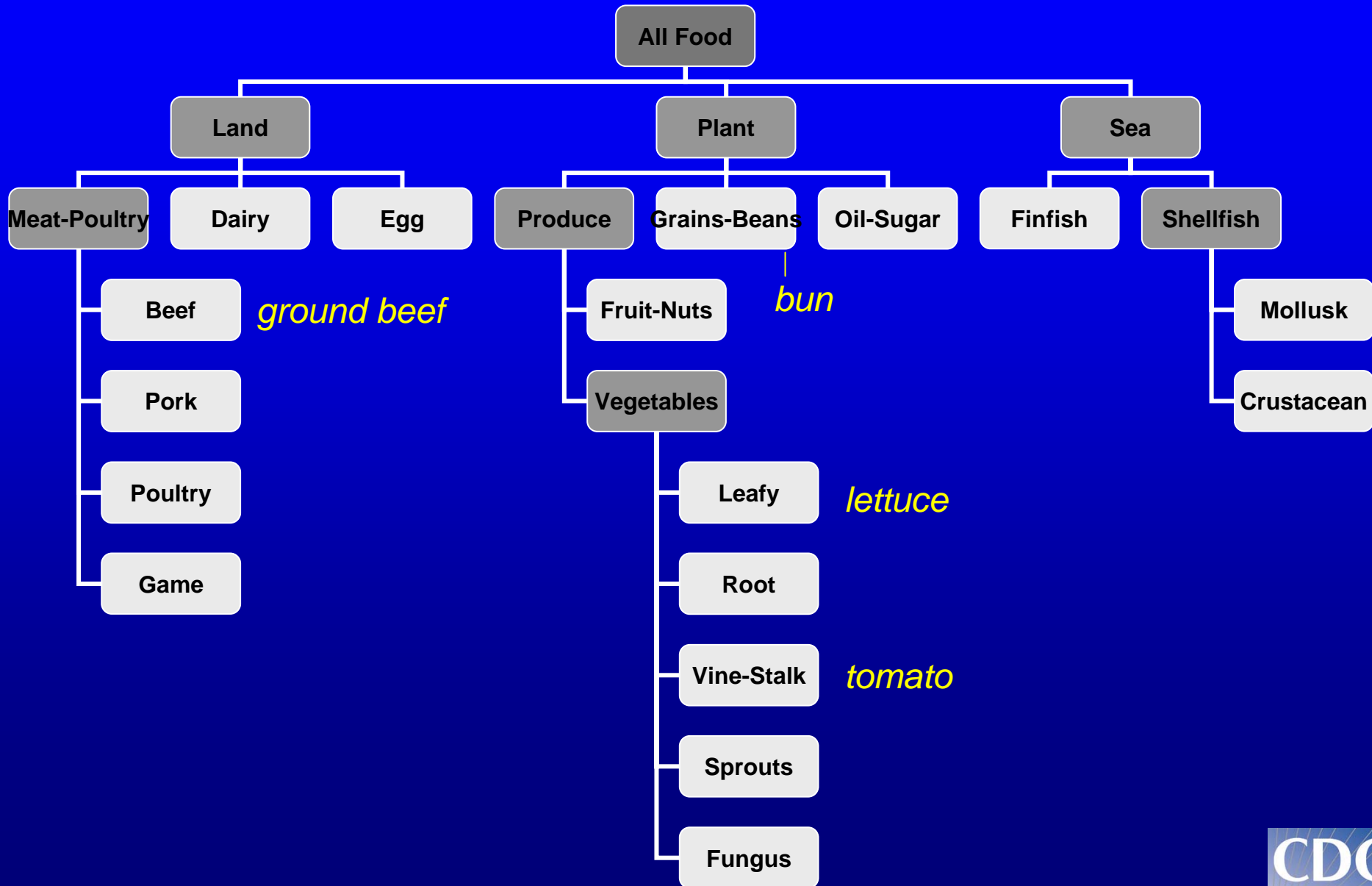
Complex food outbreak: hamburger sandwich
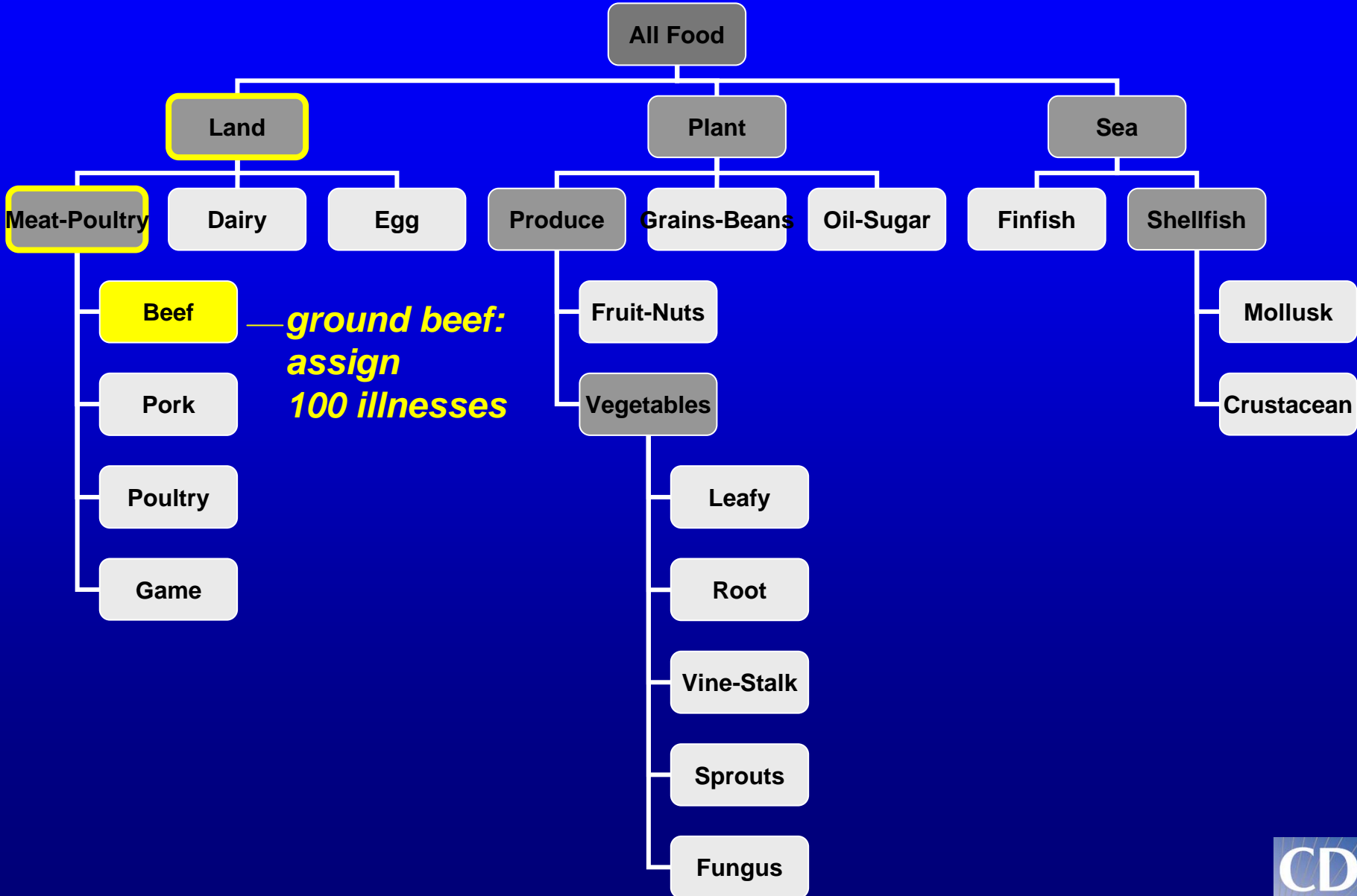
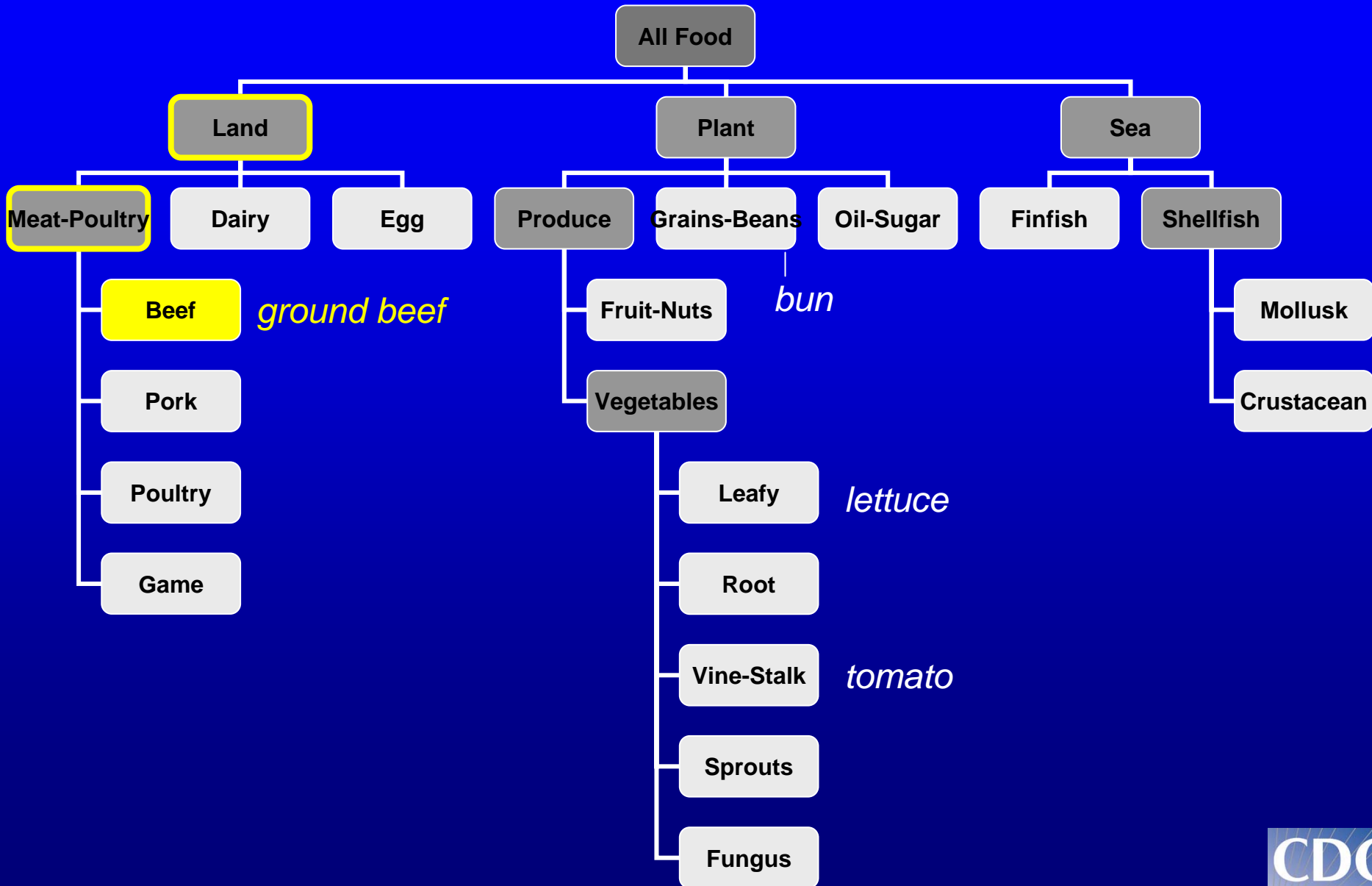# Example of outbreak from complex food item:

hamburger sandwich causing *E. coli* outbreak, causative ingredient unknown (N=100 ill)

- Cause is probably beef or lettuce
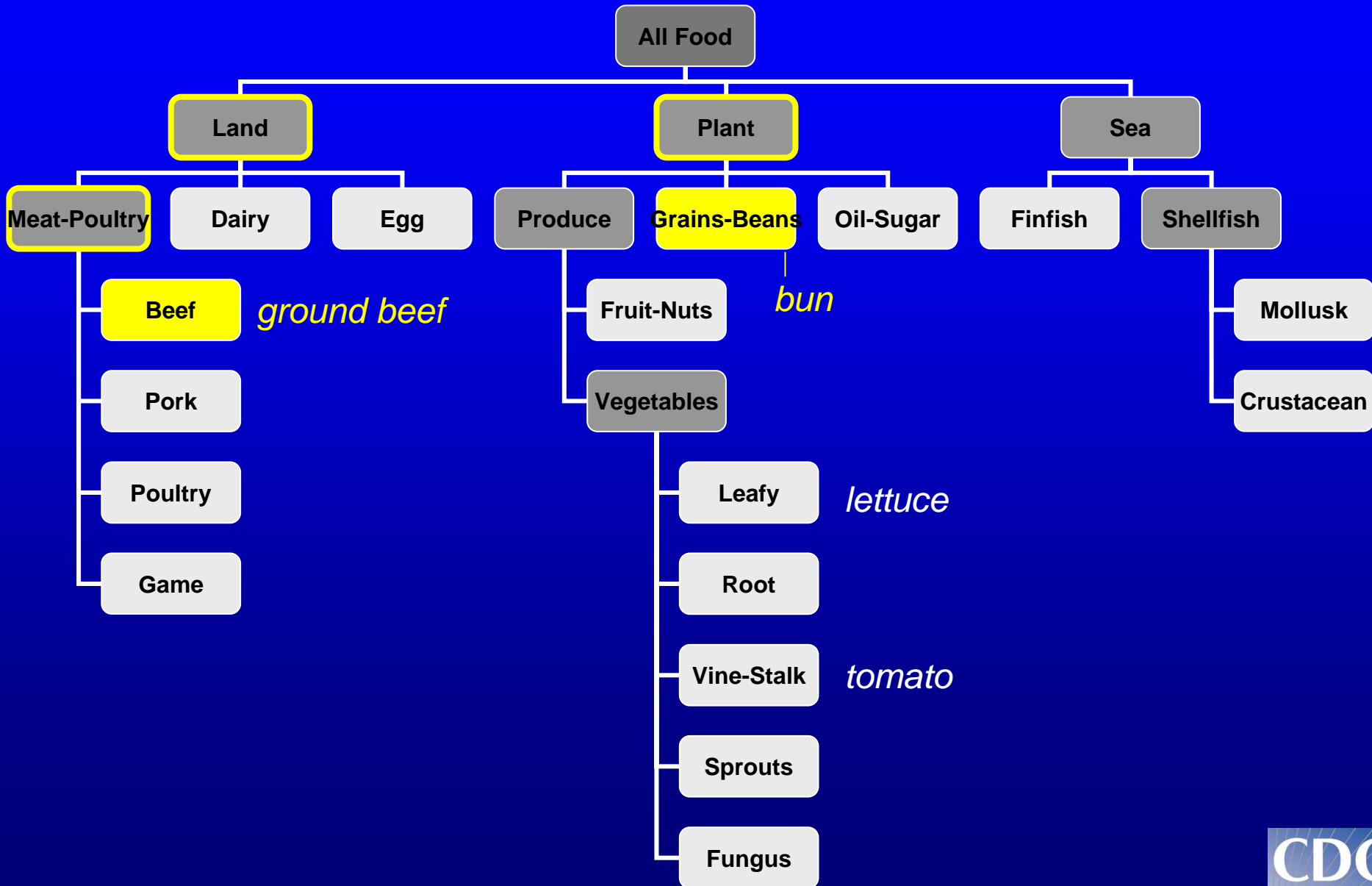 - tomato and bun never caused *E. coli* outbreak

Complex food outbreak: hamburger sandwich
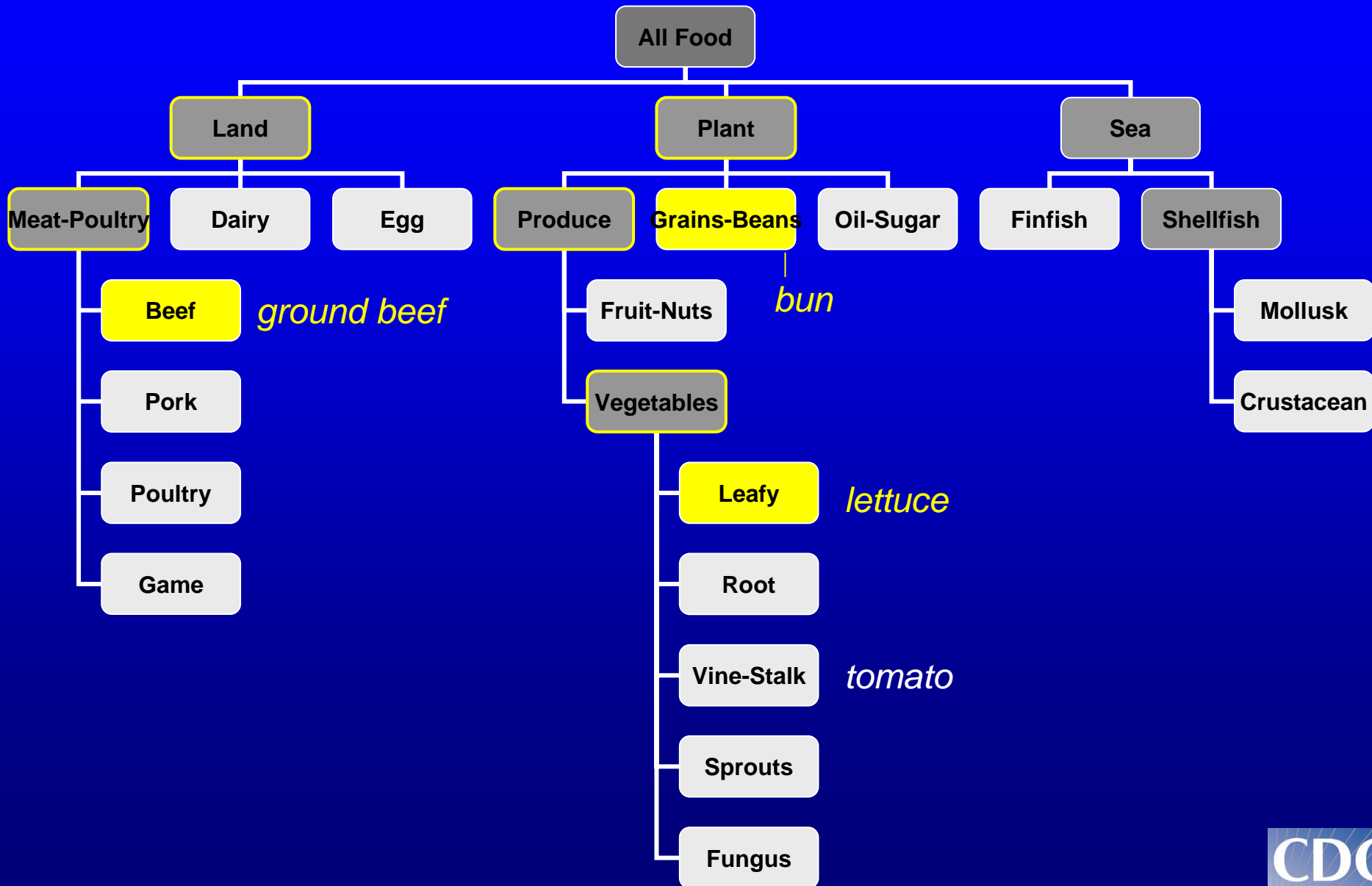
Complex food outbreak: hamburger sandwich

All Food

Land — **Plant** — **Sea**

Meat-Poultry — **Dairy** — **Egg**

Produce — **Grains-Beans** — **Oil-Sugar**

Finfish — **Shellfish**

Beef *ground beef*

Pork

Poultry

Game

Fruit-Nuts

bun

Vegetables

Mollusk

Crustacean

Leafy *lettuce*

Root

Vine-Stalk *tomato*

Sprouts

Fungus

Complex food outbreak: hamburger sandwich

All Food

Land — Plant — Sea

Land: Meat-Poultry, Dairy, Egg

Plant: Produce, Grains-Beans, Oil-Sugar

Sea: Finfish, Shellfish

Meat-Poultry: Beef *ground beef*, Pork, Poultry, Game

Produce: Fruit-Nuts, Vegetables

Grains-Beans: *bun*

Shellfish: Mollusk, Crustacean

Vegetables: Leafy *lettuce*, Root, Vine-Stalk *tomato*, Sprouts, Fungus

Complex food outbreak: hamburger sandwich

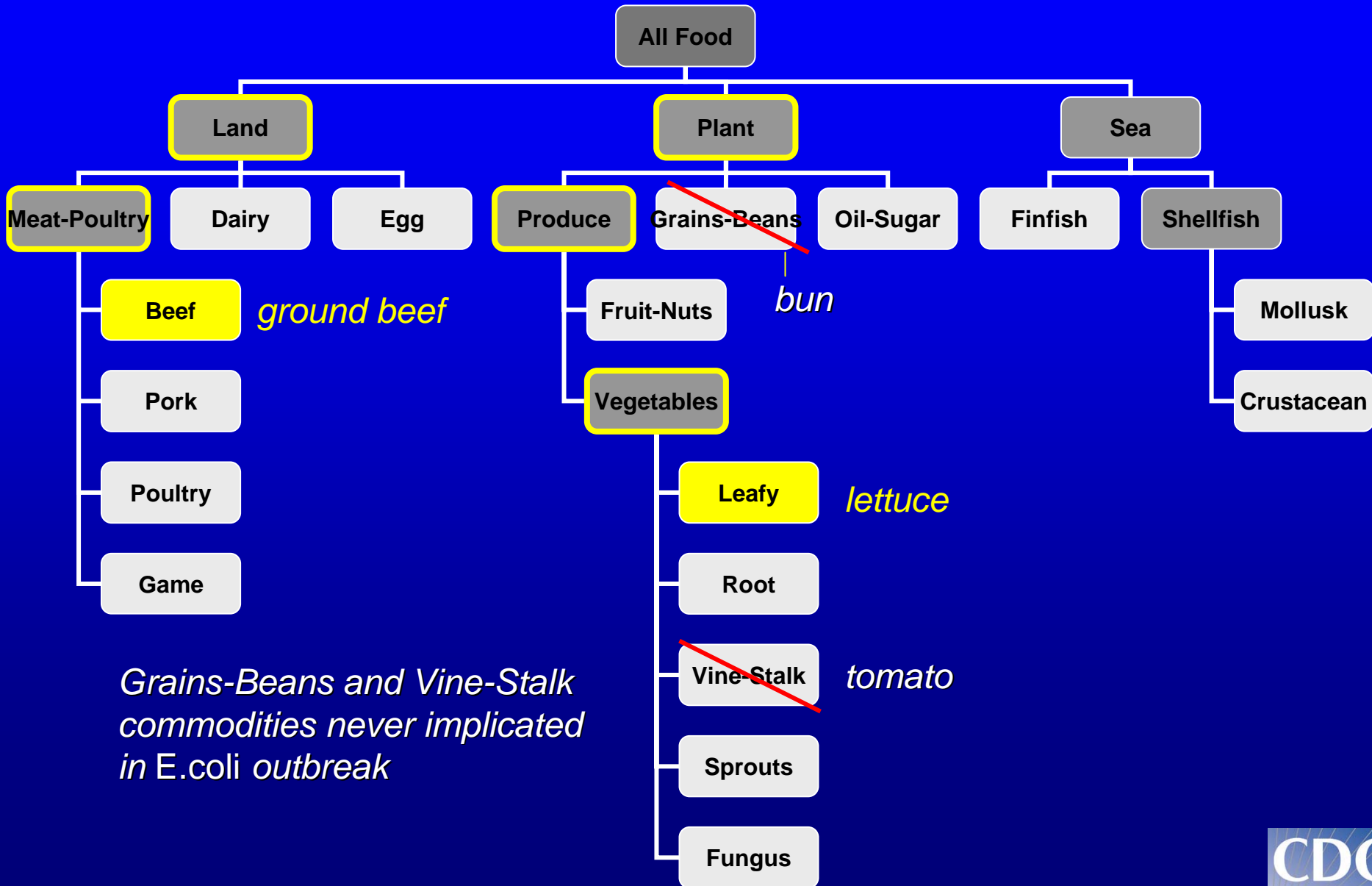# Complex food outbreak: hamburger sandwich
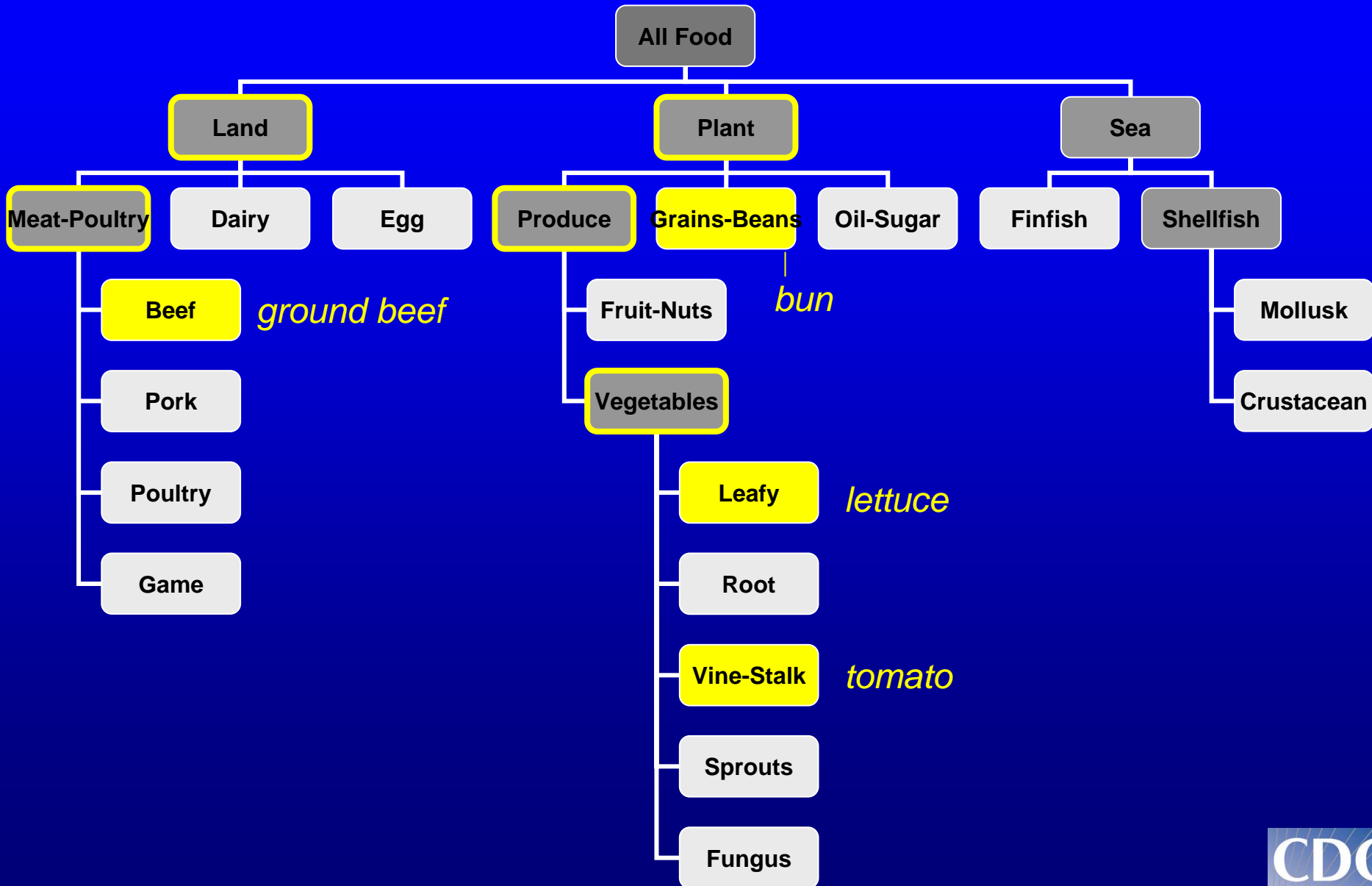
Possible methods for assigning illnesses from foods

- Method 1: use only data from outbreaks with simple foods

  - e.g., use outbreaks due to ground beef, but not hamburger sandwiches
  - problem: most implicated foods are complex
- Method 2: use data from both simple and complex foods

  - determine the ingredients of complex foods
  - model the relative importance of each ingredient

# Model the relative importance of each food ingredient

- Make high, low, and middle estimates for each ingredient

  - High: assume all the illnesses were due to this ingredient

  - Low: assume none of the illnesses were due to this ingredient

  - Middle (best method): partition the illnesses into ingredients based on data from prior outbreaks

- Only assign illnesses to commodities that have been previously shown to transmit this pathogen

Complex food outbreak: hamburger sandwich

Complex food outbreak: hamburger sandwich
Middle Estimate Method
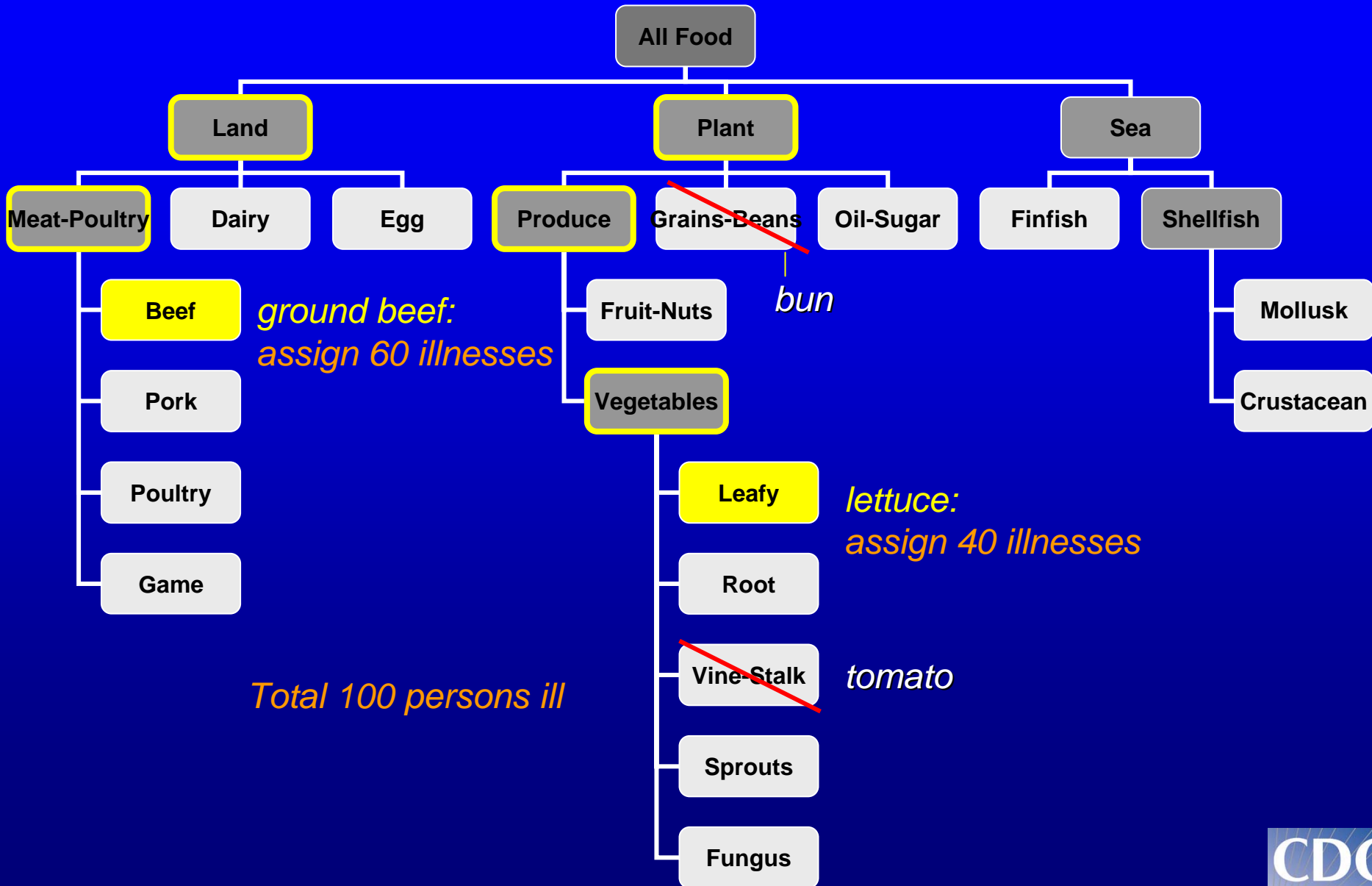
Hypothetical example, summing all outbreaks (not real data)

	Percent of illnesses in all outbreaks				Total U.S. foodborne illnesses (CDC 1999 estimates)
	Beef	**Pork**	**Veggies**	**Shellfish**	
E. coli	50%	0%	40%	0%	**62,458**

Hypothetical example, summing all outbreaks (not real data)

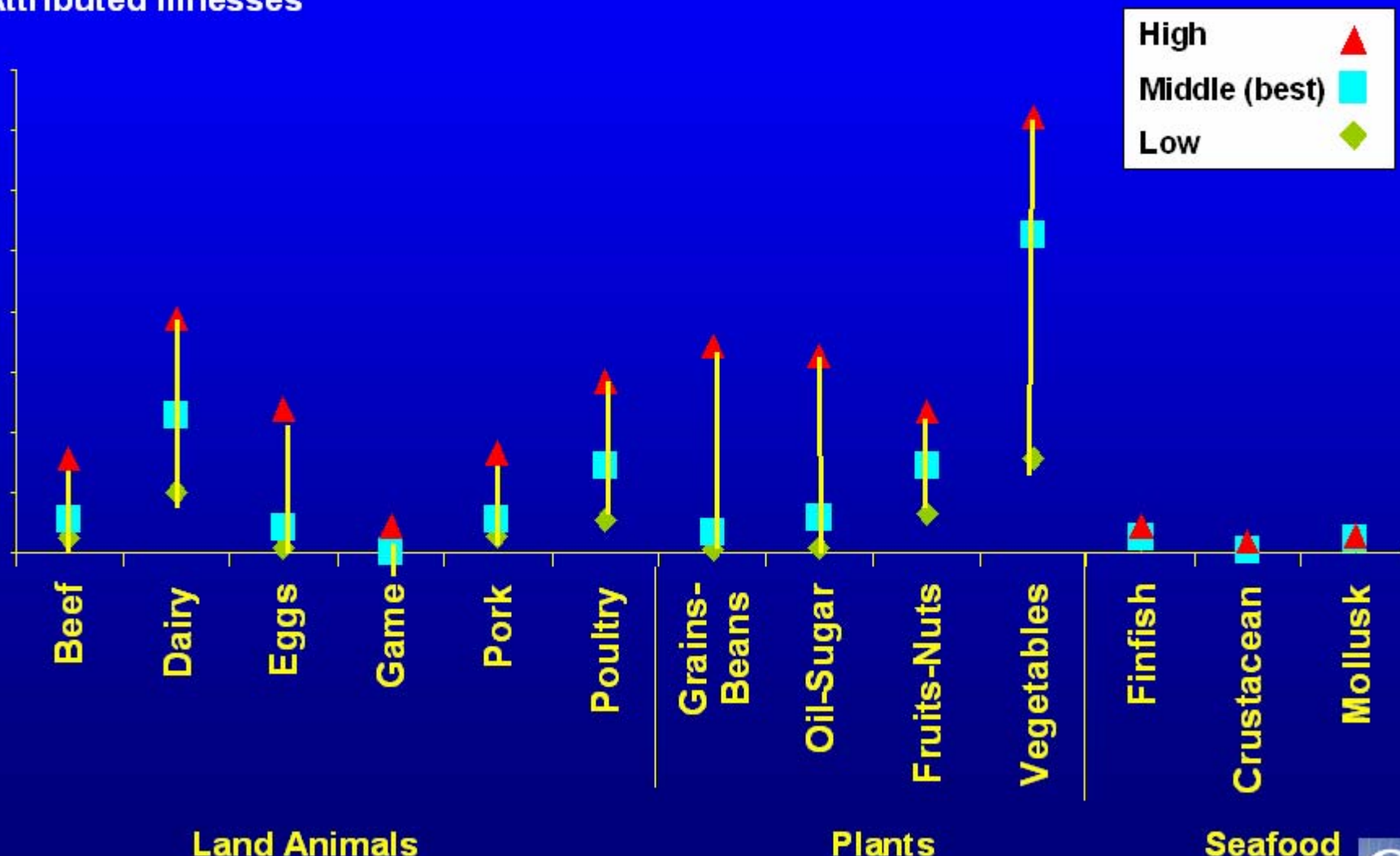|	Percent of illnesses in all outbreaks				Total U.S. foodborne illnesses (CDC 1999 estimates)
	Beef	**Pork**	**Veggies**	**Shellfish**	
E. coli	50%	0%	40%	0%	**62,458**
Vibrio	0%	0%	0%	95%	**5,122**

Hypothetical example summing all outbreaks (not real data)

	Percent of illnesses in all outbreaks				Total U.S. foodborne illnesses (CDC 1999 estimates)
	Beef	**Pork**	**Veggies**	**Shellfish**	
E. coli	50%	0%	40%	0%	**62,458**
Vibrio	0%	0%	0%	95%	**5,122**
etc…..					…..
TOTAL	**%**	**%**	**%**	**%**	**14 million**

Estimates of illnesses attributed to food commodities, U.S., 1998-2004

Attributed illnesses

Legend:
- High ▲ (red)
- Middle (best) ■ (cyan)
- Low ◆ (green)

Categories (x-axis):
Beef, Dairy, Eggs, Game, Pork, Poultry, Grains-Beans, Oil-Sugar, Fruits-Nuts, Vegetables, Finfish, Crustacean, Mollusk

Groups: Land Animals | Plants | Seafood

Preliminary data, relationships among commodities may change

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Some limitations of this method

- Based on reporting of outbreaks from health departments
  - Many outbreaks are not detected, not investigated, or not reported
  - Investigation of outbreaks is based on resources, severity of illness, and many other factors
- Based on frequency of illnesses in outbreaks
  - Some food-pathogen combinations cause few outbreaks but many non-outbreak illnesses
    - e.g., *Campylobacter* infection from eating chicken
- Analysis program only works on this "frozen" dataset
- Relies on estimates of numbers of foodborne illnesses due to each pathogen published in 1999

Future plans

- Create computer programs to apply method to later years

- Create models to measure trends

- Revise estimates of the numbers of foodborne illnesses due to each pathogen (Mead 1999)

- Improve foodborne outbreak investigation and reporting

  - so more outbreaks are reported to the eFORS database

    - so have more data points

- Modify the model to use information from studies of non-outbreak illnesses

Summary

- **Outbreak data can provide estimates of the amount of foodborne illness due to each food commodity, including**
  - all foods that have caused outbreaks
  - all pathogens that have caused outbreaks
  - data from complex foods
- **Method relies on estimates of the number of U.S. illnesses due to each agent**
- **Future possibilities**
  - measuring trends
  - adding information from non-outbreak illnesses

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The conclusions and opinions expressed herein are those of the presenter and do not necessarily represent the views or policies of CDC and DHHS