CALORIE COUNTING WITH JACQUARD

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- **Essential contributions from**
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- **Sponsored by IPE Core Platform**
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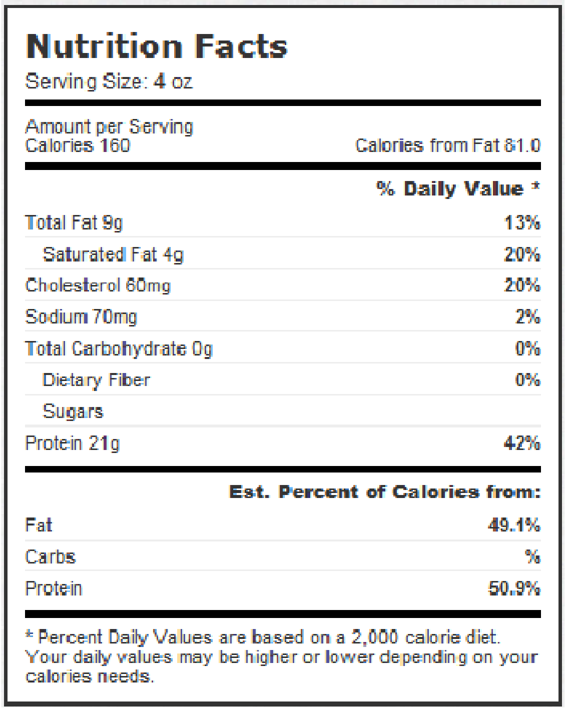
MOTIVATING SAMPLE PROBLEM

- **<u>How to write apps</u> to manipulate standard Nutrition-Facts Labels (NFLs)?**
- **e.g.: (1) Check Consistency (2) Compute new labels from recipes on-the-fly**
- **Jacquard enables techniques that are *<u>impossible via ordinary programming</u>* in JavaScript or C# and *<u>easy with symbolic expressions</u>***



Nutrition Facts

Serving Size: 4 oz

Amount per Serving	
Calories 160	Calories from Fat 81.0

	% Daily Value *
Total Fat 9g	**13%**
Saturated Fat 4g	**20%**
Cholesterol 60mg	**20%**
Sodium 70mg	**2%**
Total Carbohydrate 0g	**0%**
Dietary Fiber	**0%**
Sugars	
Protein 21g	**42%**

	Est. Percent of Calories from:
Fat	**49.1%**
Carbs	**%**
Protein	**50.9%**

* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calories needs.

- Problems with NFLs:
- Confusing information; confusing layout
- Many units: ounces, percents, calories, grams, milligrams
- Separate calories from fat & carbs, not percents
- Check for accuracy: Does serving size and total calories match sum of components? If not, why not? Liability exposure?

WHAT IS JACQUARD? http://bing/wiki/Jacquard

- **General-purpose distributed Expression Evaluator**
- **Value prop to devs: apps will be smaller, safer; more expressive, distributed, compatible, reusable**
- **Expression Evaluators run everywhere: client, server, web service**
- **Supports Symbolic, Numeric, Logic, Functional, Object models**
- **Compat with JSON, AJAX, Node.Js (try http://jacquard.msproto.net/)**
- **(soon) Compat with .NET LINQ Expressions and Native code**
- **Uses established techniques -- low "science" risk**
- **Pattern Matching -- "Regular Expressions" for whole expressions, not just strings**
- **Term Rewriting: "when you match this pattern, replace it with that expression after substituting actual values for variables"**
- **Built-in to the Knowledge Store from Day Zero: Expressions are Entities,**
  Fully self-describing and reflective

DO DEVS NEED GENERAL COMPUTATION?

- **Most searches already involve computations**
  - Route plans, Travel proposals
  - Event-sequence schedules
  - Price quotes, loan proposals
  - Trading, portfolio optimization, risk analysis
  - Even calorie counting (it’s big business)
- **Jacquard makes computations more robust, powerful, distributed, reusable**
  - Keep Computations and other Knowledge **in exactly the same format**
  - Index and retrieve **expressions as Merino Entities**
  - Power means bang-for-the-buck: **more computation for less script**
- **Wolfram Alpha blazed the trail**
  - Mission statement similar to Merino’s
  - They are 100% based on an expression language -- *Mathematica* -- which inspired Jacquard
  - They curate; we crowdsource

THE SCENARIO: WHERE’S THE BEEF?

- **Encode Nutrition-Fact Label in JavaScript (C# similar); contrast Jacquard:**

JavaScript

```
var burgerNutritionFacts =
{ ServingSize        :   4  , // Ounce
  AmountPerServing   : 160  , // Calorie
  CaloriesFromFat    :  81.0, // Calorie
  SaturatedFat       :   4  , // Gram
  Cholesterol        :  60  , // Milligram
  Sodium             :  70  , // Milligram
  DietaryFiber       :   0  , // Gram
  Sugars             :   0  , // Gram
  TotalFat           :   9  , // Gram
  Protein            :  21  , // Gram
  TotalCarbohydrate  :   0  , // Gram
};
```

Jacquard

```
burgerNutritionFacts = {
  ServingSize        ->   4   * Ounce,
  AmountPerServing   -> 160   * Calorie,
  CaloriesFromFat    ->  81.0 * Calorie,
  SaturatedFat       ->   4   * Gram,
  Cholesterol        ->  60   * Milli Gram,
  Sodium             ->  70   * Milli Gram,
  DietaryFiber       ->   0   * Gram,
  Sugars             ->   0   * Gram,
  TotalFat           ->   9   * Gram,
  Protein            ->  21   * Gram,
  TotalCarbohydrate  ->   0   * Gram
}
```

- **OBSERVATION: In JavaScript, NO innate way to carry units**
- **Imagine this is written by OCR program, not by hand**
- **Jacquard: *4 * Ounce* means “4 times the symbolic constant *Ounce*”**
- **Jacquard: *Everything is an Expression* -- No Exceptions**
- **Computing in Jacquard is Evaluating Expressions, not “running code”**

DO THE WEIGHTS ADD UP?

JavaScript	Jacquard

`var addWeights = function(nutritionFacts) {`
`return nutritionFacts.TotalFat +`
`       nutritionFacts.DietaryFiber +`
`       nutritionFacts.Protein +`
`       nutritionFacts.Cholesterol +`
`       nutritionFacts.Sodium +`
`       nutritionFacts.TotalCarbohydrate;`
`};`
`document.writeln(addWeights(burgerNutritionFacts));`
	`TotalFat +`
	` DietaryFiber +`
	` Protein +`
	` Cholesterol +`
	` Sodium +`
	` TotalCarbohydrates`
	` /. burgerNutritionFacts`

160	30 Gram + 130 Gram Milli

- **NOTE: Jacquard catches the mistake!**
  In JavaScript, only the programmer can catch it, and only by head compiling
- **NOTE: this 160 is highly suspect: will see later**
- **NOTE: Units mistakes can cost billions**
  - 1999: NASA Mars Climate Observer crashed over force in Newtons versus pounds-force
  - Who would be liable for a faulty NFL implicated in a diabetic or cardiac incident?
- **OBSERVATION: object access (slash-dot) *after* the arithmetic, not before**
- **Object access distributes across the sum**

HOW DOES IT WORK?

- **Not like ordinary programming; *unbound variables are NOT errors***
- **Symbolic constants are like variables that just evaluate to themselves**
- **They cancel out of ratios ...**

$$\frac{16\ \mathtt{Ounce}}{\mathtt{Pound}} * 27\ \mathtt{Pound}$$

```
432 Ounce
```

- **... and distribute over sums**

```
2 Ounce + 4 Ounce
```

```
6 Ounce
```

APPLYING OBJECTS TO EXPRESSIONS

- **This is a symbolic expression; it evaluates to itself:**

```
TotalFat + DietaryFiber + Protein +
  Cholesterol + Sodium + TotalCarbohydrate
```

```
Cholesterol + DietaryFiber + Protein + Sodium + TotalCarbohydrate + TotalFat
```

- **Save it in a variable ...**

```
nflSummary = TotalFat + DietaryFiber + Protein +
  Cholesterol + Sodium + TotalCarbohydrate
```

```
Cholesterol + DietaryFiber + Protein + Sodium + TotalCarbohydrate + TotalFat
```

- **... Use it in later computations ...**

JACQUARD OBJECT = LIST OF REPLACEMENT RULES

```
(burgerNutritionFacts = {ServingSize → 4 * Ounce,
    AmountPerServing → 160 * Calorie,
    CaloriesFromFat → 81.0 * Calorie,
    SaturatedFat → 4 * Gram, Cholesterol → 60 * Milli * Gram,
    Sodium → 70 Milli * Gram, DietaryFiber → 0 * Gram,
    Sugars → 0 * Gram, TotalFat → 9 * Gram, Protein → 21 * Gram,
    TotalCarbohydrate → 0 * Gram}) // gridRules
```

ServingSize	4 Ounce
AmountPerServing	160 Calorie
CaloriesFromFat	81. Calorie
SaturatedFat	4 Gram
Cholesterol	60 Gram Milli
Sodium	70 Gram Milli
DietaryFiber	0
Sugars	0
TotalFat	9 Gram
Protein	21 Gram
TotalCarbohydrate	0

APPLY THE OBJECT TO THE EXPRESSION

```
nflSummary   /.   burgerNutritionFacts
```

```
30 Gram + 130 Gram Milli
```

- **Long form of the same expression**

```
ReplaceAll[ nflSummary, burgerNutritionFacts ]
```

```
30 Gram + 130 Gram Milli
```

- **Objects are collections of replacement rules**
- ***Applying rules* is like *calling functions***
- **Objects act like collections of functions**
  - This is also true in ordinary object-oriented programming
  - Methods are always functions
  - Properties are backed by functions (get, set) in ECMAScript & C#

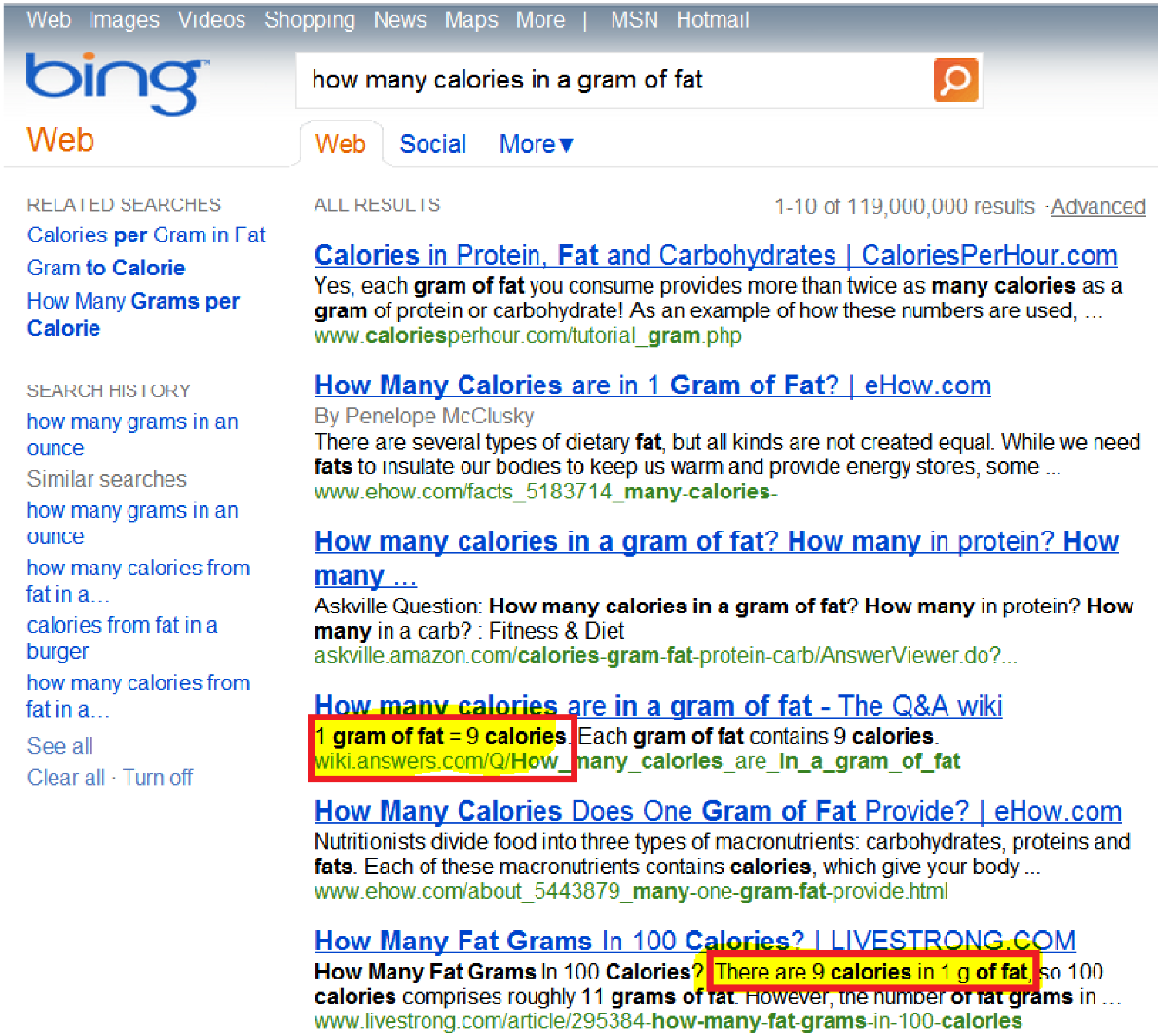
MORE NFL: ADD UP THE CALORIES

- **Beef-up the object**

```
(beefedUpBurgerNutritionFacts = {ServingSize → 4 * Ounce,
    AmountPerServing → 160 * Calorie, CaloriesFromFat → 81.0 * Calorie,
    SaturatedFat → 4 * Gram * saturated fat,
    Cholesterol → 60 * Milli * Gram * cholesterol,
    Sodium → 70 Milli * Gram * sodium, DietaryFiber → 0 * Gram * fiber,
    Sugars → 0 * Gram * sugar, TotalFat → 9 * Gram * fat,
    Protein → 21 * Gram * protein,
    TotalCarbohydrate → 0 * Gram * carbohydrate}) // gridRules
```

ServingSize	4 Ounce
AmountPerServing	160 Calorie
CaloriesFromFat	81. Calorie
SaturatedFat	4 fat Gram saturated
Cholesterol	60 cholesterol Gram Milli
Sodium	70 Gram Milli sodium
DietaryFiber	0
Sugars	0
TotalFat	9 fat Gram
Protein	21 Gram protein
TotalCarbohydrate	0

MINE FOR CALORIE FACTS


Web Images Videos Shopping News Maps More | MSN Hotmail
bing
Web
how many calories in a gram of fat
Web Social More ▾

RELATED SEARCHES

- Calories **per** Gram in Fat
- Gram **to Calorie**
- How Many **Grams per Calorie**

SEARCH HISTORY

- how many grams in an ounce
- Similar searches
- how many grams in an ounce
- how many calories from fat in a...
- calories from fat in a burger
- how many calories from fat in a...
- See all
- Clear all · Turn off

ALL RESULTS 1-10 of 119,000,000 results · Advanced

Calories in Protein, **Fat** and Carbohydrates | **CaloriesPerHour.com**
Yes, each **gram of fat** you consume provides more than twice as **many calories** as a **gram** of protein or carbohydrate! As an example of how these numbers are used, ...
www.**calories**perhour.com/tutorial_**gram**.php

How Many Calories are in 1 **Gram of Fat**? | eHow.com
By Penelope McClusky
There are several types of dietary **fat**, but all kinds are not created equal. While we need **fats** to insulate our bodies to keep us warm and provide energy stores, some ...
www.ehow.com/facts_5183714_**many-calories**-

How many calories in a gram of fat? **How many** in protein? **How many** ...
Askville Question: **How many calories in a gram of fat**? **How many** in protein? **How many** in a carb? : Fitness & Diet
askville.amazon.com/**calories-gram-fat**-protein-carb/AnswerViewer.do?...

How many calories are in a **gram of fat** - The Q&A wiki
1 **gram of fat** = 9 **calories**. Each **gram of fat** contains 9 **calories**.
wiki.answers.com/Q/**How_many_calories**_are_**in_a_gram_of_fat**

How Many Calories Does One **Gram of Fat** Provide? | eHow.com
Nutritionists divide food into three types of macronutrients: carbohydrates, proteins and **fats**. Each of these macronutrients contains **calories**, which give your body ...
www.ehow.com/about_5443879_**many**-one-**gram-fat**-provide.html

How Many Fat Grams In 100 **Calories**? | LIVESTRONG.COM
How Many Fat Grams In 100 **Calories**? There are 9 **calories** in 1 g **of fat**, so 100 **calories** comprises roughly 11 **grams of fat**. However, the number **of fat grams** in ...
www.livestrong.com/article/295384-**how-many-fat-grams**-in-100-**calories**

ENCODE CALORIE FACTS AS RULES

```
(calorieFacts = {
    Gram * saturated * fat → 9 * Calorie,
    Gram * fat → 9 * Calorie,
    Gram * sugar → 4 * Calorie,
    Gram * carbohydrate → 4 * Calorie,
    Gram * protein → 4 * Calorie,
    Gram * cholesterol → 0 * Calorie,
    Gram * fiber → 0 * Calorie,
    Gram * sodium → 0 * Calorie,
    Milli * Gram → Gram * 0.001}) // gridRules
```

fat Gram saturated	9 Calorie
fat Gram	9 Calorie
Gram sugar	4 Calorie
carbohydrate Gram	4 Calorie
Gram protein	4 Calorie
cholesterol Gram	0
fiber Gram	0
Gram sodium	0
Gram Milli	0.001 Gram

APPLY CALORIE FACTS & SUMMARIZE

```
(beefedUpBurgerNutritionFacts /. calorieFacts) // gridRules
```

ServingSize	4 Ounce
AmountPerServing	160 Calorie
CaloriesFromFat	81. Calorie
SaturatedFat	36 Calorie
Cholesterol	0
Sodium	0
DietaryFiber	0
Sugars	0
TotalFat	81 Calorie
Protein	84 Calorie
TotalCarbohydrate	0

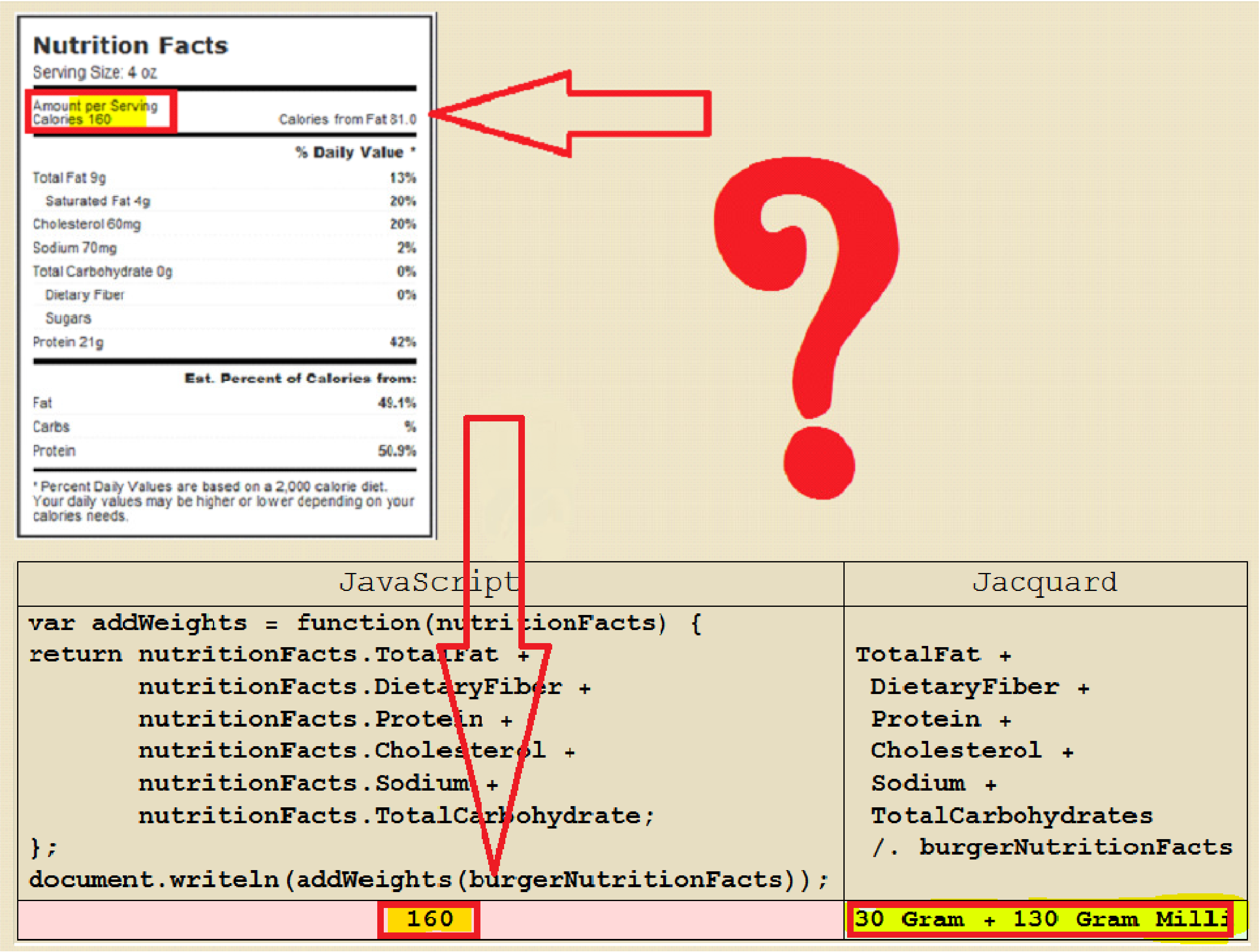
- **This is just a new object: APPLY IT to our first sum expression!**

```
nflSummary /. beefedUpBurgerNutritionFacts /. calorieFacts
```

```
165 Calorie
```

- **but but but -- they said 160 Calorie? What’s up with *that*?**

UH-OH! VERY SUSPECT 160 HERE



Nutrition Facts

Serving Size: 4 oz

Amount per Serving Calories 160	Calories from Fat 81.0
	% Daily Value *
Total Fat 9g	13%
Saturated Fat 4g	20%
Cholesterol 60mg	20%
Sodium 70mg	2%
Total Carbohydrate 0g	0%
Dietary Fiber	0%
Sugars	
Protein 21g	42%
	Est. Percent of Calories from:
Fat	49.1%
Carbs	%
Protein	50.9%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calories needs.

JavaScript	Jacquard

`var addWeights = function(nutritionFacts) {`
`return nutritionFacts.TotalFat +`
`        nutritionFacts.DietaryFiber +`
`        nutritionFacts.Protein +`
`        nutritionFacts.Cholesterol +`
`        nutritionFacts.Sodium +`
`        nutritionFacts.TotalCarbohydrate;`
`};`
`document.writeln(addWeights(burgerNutritionFacts));`
	`TotalFat +`
	` DietaryFiber +`
	` Protein +`
	` Cholesterol +`
	` Sodium +`
	` TotalCarbohydrates`
	` /. burgerNutritionFacts`

160	30 Gram + 130 Gram Milli

;

ORIGINAL AUTHORS MADE A MISTAKE?

- **Data adds up to 165 calories; NFL reports 160**
- **We earlier found 160, without units, in a wrong weight calculation**
- **Hypothesis: Programmers made the obvious mistake and then *also* copied the bad weight output into the wrong calorie slot**
- **Without units, it's probably an honest mistake, but too easy to make and compound**
- **If we carry units, this kind of mistake requires willful malfeasance**
  - Symbolic expressions make the mistake nearly impossible to miss

- **NASA recommended research in units processing after the Mars crash**
  - Commercial manifestations include Sun's FORTRESS language and .NET's F#
  - Symbolic programs like Macsyma, Maple and *Mathematica* have had units of measure for decades

IT’S WORSE!

- **We found 30 Gram + 130 Gram Milli**
- **Check against the serving size -- use our original weight-finding expressions:**

```
Convert[ nflSummary /. burgerNutritionFacts, Ounce ]
```

```
1.0628 Ounce
```

- **NFL says serving size = 4 ounces: almost 3 ounces of MISSING MASS?**
- **Willful underreporting?**
- **Unreported inert ingredients like water?**
- **We can't say from the data!**
- **Can we trust the Calories per Serving results?**
- **BOTTOM LINE: Jacquard gives the IPE Developer clear opportunity to write safer, smaller, more disciplined (i.e., better), apps**

TAKEAWAYS

- **Computing with Expressions beats computing with Code**
  - short, clear, expressive, sandboxable
- **Authoring environments in *Mathematica* now and (planned) Cloud9**
- **Interop with JavaScript, C#, C++**
- **Reactive & Enumerative LINQ is a Given**
- **Expressions are just more knowledge in the graph**
- **Expressions are universal**
  - Supports Symbolic, Numeric, Logic, Functional, Object models
- **Evaluators bring Expressions to life**
  - Evaluators everywhere: agent, cloud, desktop, edge, all devices
  - Reference Evaluator in JavaScript; more evaluators in C#/F#, Java/Scala/Kiama, C++/Maude

THE COMPUTATION IS VERY SHORT

```
nflSummary
```

```
Cholesterol + DietaryFiber + Protein + Sodium + TotalCarbohydrate + TotalFat
```

```
beefedUpBurgerNutritionFacts
```

```
{ServingSize → 4 Ounce, AmountPerServing → 160 Calorie, CaloriesFromFat → 81. Calorie,
 SaturatedFat → 4 fat Gram saturated, Cholesterol → 60 cholesterol Gram Milli, Sodium → 70 Gram Milli sodium,
 DietaryFiber → 0, Sugars → 0, TotalFat → 9 fat Gram, Protein → 21 Gram protein, TotalCarbohydrate → 0}
```

```
calorieFacts
```

```
{fat Gram saturated → 9 Calorie, fat Gram → 9 Calorie, Gram sugar → 4 Calorie, carbohydrate Gram → 4 Calorie,
 Gram protein → 4 Calorie, cholesterol Gram → 0, fiber Gram → 0, Gram sodium → 0, Gram Milli → 0.001 Gram}
```

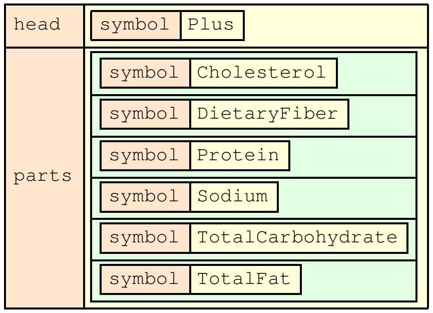
```
nflSummary/.beefedUpBurgerNutritionFacts/.calorieFacts
```

```
165 Calorie
```

EXPRESSIONS AS ENTITIES

- **Encode in JSON**

```
nflSummary//rulesFromExpression//gridRules
```



head	symbol	Plus
parts	symbol	Cholesterol
	symbol	DietaryFiber
	symbol	Protein
	symbol	Sodium
	symbol	TotalCarbohydrate
	symbol	TotalFat

- **Replace symbols with URIs in the Expressions Taxonomy / Ontology:**

```
nflSummary/.{Plus→
{"$meta"→{"knol"→"knol:knowledge.merino.com/",
  "expressions"→"knol:expressions.merino.com/"},
  "knol_identity"→"knol:expressions.merino.com/WellKnown/Plus",
  "knol_types/is-a"→"knol:expressions.merino.com/types/builtIn",
  "expressions_builtIn/name"→"Plus","expressions_builtIn/Attributes"→
    {"Flat", "Listable","NumericFunction","OneIdentity","Orderless","Protected",
    {"Default"→"knol:expressions.merino.com/values/builtIn/Integers/Constants/Zero"}},
  "expressions_builtIn/Doclet"→"knol:music.merino.com/expressions/Doclet/Plus"}};
```

ONCE IN MERINO

- **Index, Find, Abstract, Compose new Expressions**
- **Self-describing at all levels**
- **Grow Expression store by crowdsourcing computations**
- **Evaluate close to the data**
  - for Privacy (intelligent agent)
  - for Perf (IOC / Reactive framework)
  - for Affinity to data sources (RESTLINQ & bandwidth saving)
- **Semantic queries enabled by *Abstract Query DSLs***
  - Example: you want to build a computation that computes *the average age of singers in the US*
  - This is similar to a computation of *maximum salaries of CEOs in Kentucky*
  - Abstract Query DSLs find the most abstract form of the query
- **Create Abstract Query DSLs automatically from BNFs of specialized computations**

OTHER SCENARIOS

- **Get Me to the Airport on Time**
  - **Reactive** LINQ, distributed example monitoring traffic, current location, and flight status
- **Find me a Movie**
  - Distributed **conversational workflow**
- **What is the Average Age of Pop Singers in the US?**
  - Example of large class of **map-reduce style** queries
- **“If you Drive Out of Your Way, I’ll Give You a Discount”**
  - **Partial-trust, geospatial**, secret auction process

- **We need more -- send us your ideas!**

BONUS ROUND: COMPUTING LABELS ON-THE-FLY

- **What would the NFL be for your mom's Pasta Primavera recipe?**
- ***Only you* know the recipe; no point searching**
- **Compute it on-the-fly by adding up the NFLs of the ingredients**
- **NFLs for real-world recipes could be a whole business built on Merino**

- **GEEKNOTE: This is a vector-space sum: unit vectors are the NFLs for the ingredients, coefficients are the amounts from your recipe**

- **YOUR SECRET RECIPE FROM MOM**

```
myRecipe={
1.0 Tablespoon "olive oil",
16.0 Ounce "zucchini",
3.5 Teaspoon "salt",
1.5 Pound "eggplant",
1.0 "onion",
2.0 "bell pepper",
14.5 Ounce "stewed tomato",
0.5 Teaspoon "black pepper",
0.5 Teaspoon "dried basil",
0.5 Teaspoon "sugar",
12.0 Ounce "pasta",
0.25 Cup "parmesan cheese"};
```

FINAL RECIPE, FEEDING SIX

```
scaleNfl[Fold[sumNfls, First[scaledNfls], Rest[scaledNfls]], 1 / 6] // gridRules
```

name	bell pepper + black pepper + dried basil + eggplant + olive oil + onion + parmesan cheese + pasta + salt + stewed tomato + sugar + zucchini
serving size	368.02 Gram
total calories	309.72 Calorie
fat calories	58.413 Calorie
total fat	6.546 Gram
% daily total fat	9.8998 Percent
saturated fat	1.5959 Gram
% daily saturated fat	7.5358 Percent
trans fat	0
cholesterol	44.422 Gram
% daily cholesterol	14.795 Percent
sodium	1.7696 Gram
% daily sodium	73.6 Percent
total carbohydrates	53.543 Gram
% daily carbohydrates	17.71 Percent
dietary fiber	6.8463 Gram
%daily dietary fiber	25.73 Percent
sugars	5.8525 Gram
protein	12.1 Gram
% daily protein	2.7658 Percent
vitamin A	13.434 Percent
vitamin C	107.62 Percent
calcium	11.903 Percent
iron	19.675 Percent

JACQUARD FOR THIS APP

- **PLAN:**

1. Convert recipe volumes and weights into standardized weights in grams:

```
(recipeInGrams =
   Map[Function[ingredient, Convert[ingredient, Gram]], myRecipe /. volumeRules /. wholeItemRules]) // gridRules
```

```
12.713 olive oil Gram
453.59 zucchini Gram
19.915 salt Gram
680.39 eggplant Gram
151.2 onion Gram
113.4 bell pepper Gram
411.07 stewed tomato Gram
1.05 black pepper Gram
0.5 dried basil Gram
2.1 sugar Gram
340.19 pasta Gram
22. parmesan cheese Gram
```

2. Data-mine basic NFLs for the ingredients

name	black pepper
serving size	1. Tablespoon
total calories	16 Calorie
fat calories	2 Calorie
total fat	0
% daily total fat	0
saturated fat	0
% daily saturated fat	0
trans fat	0
cholesterol	0
% daily cholesterol	0
sodium	3 Gram Milli
% daily sodium	0
total carbohydrates	4 Gram
% daily carbohydrates	1. Percent
dietary fiber	2 Gram
%daily dietary fiber	7 Percent
sugars	0
protein	1. Gram
% daily protein	0
vitamin A	0
vitamin C	2 Percent
calcium	3 Percent
iron	10 Percent

3. Normalize ingredient NFLs into “per-gram” from “per serving size”

name	black pepper
serving size	1. Gram
total calories	2.5397 Calorie
fat calories	0.31746 Calorie
total fat	0.
% daily total fat	0.
saturated fat	0.
% daily saturated fat	0.
trans fat	0.
cholesterol	0.
% daily cholesterol	0.
sodium	0.00047619 Gram
% daily sodium	0.
total carbohydrates	0.63492 Gram
% daily carbohydrates	0.15873 Percent
dietary fiber	0.31746 Gram
%daily dietary fiber	1.1111 Percent
sugars	0.
protein	0.15873 Gram
% daily protein	0.
vitamin A	0.
vitamin C	0.31746 Percent
calcium	0.47619 Percent
iron	1.5873 Percent

4. Multiply each normalized NFL by the recipe amount in grams
5. Add up all the NFLs, slot-by-slot

- **1. Convert recipe volumes and weights into standardized weights in grams**
- **Data-mine for density facts**

```
density["olive oil"] = Mean[{6.68,7.67}] * Pound / Gallon;
density["salt"] = 5.69 Gram / Teaspoon;
density["black pepper"] = 2.1 Gram / Teaspoon;
density["dried basil"] = 1.0 Gram / Teaspoon;
density["sugar"] = 4.2 Gram / Teaspoon;
density["parmesan cheese"] = 88 Gram / Cup;

density[___] = 1.0;
```

- **This is in the form of a standard Merino <u>fact base</u>:**
- **Predicate (density) assertions about entities (“olive oil”)**

COMPUTE GRAMS PER TARGET VOLUME FROM DENSITY
args: [TargetVolume (*e.g.Tablespoon*), DataMinedDensity]

- If you match a *target volume* (say, Tablespoon) and a data-mined density of the form *d(number)* times *weight(symbol)* divided by *volume(symbol)*, replace the match with the computed weight in grams

```
gramPerTargetVolumeFromDensity[
  targetVolume_,
  d_?NumberQ * weight_ / volume_] :=

 (d * Convert[weight, Gram]) / Convert[volume, targetVolume]
```

■ WEIGHT RULE FROM QUANTIFIED INGREDIENT VOLUME
args: [Volume *e.g. 4 Teaspoon*]

- This is **a rule that creates new rules**!, i.e., an *object factory*
- If you match a *quantified ingredient volume* of the form *quantity(number)* times *ingredient(symbol)* times *volume(one of a fixed collection of symbols)*, then replace the match with a new RULE that will convert the weight of the quantified ingredient volume into grams
- Add a default rule that produces the empty list for any other match since we use this in LINQ’s *SelectMany*

```
weightRuleFromQuantifiedIngredientVolume[quantity_?NumberQ  *  ingredient_  *volume : (Teaspoon | Tablespoon | Cup | FluidOunce | Pint | Gallon)] :=

  ingredient * volume →
   ingredient * gramPerTargetVolumeFromDensity[volume,
     density[ingredient]] * volume;

weightRuleFromQuantifiedIngredientVolume[___] := {}
```

■ VOLUME RULES

- The original recipe is an object containing quantified ingredient volumes
- Convert the recipe into a new object that specifies all weights in Grams
- *SelectMany* is regular critter for object-to-object transforms

```
(volumeRules = SelectMany[myRecipe, weightRuleFromQuantifiedIngredientVolume]) // gridRules
```

olive oil Tablespoon	12.713 olive oil Gram
salt Teaspoon	5.69 salt Gram
black pepper Teaspoon	2.1 black pepper Gram
dried basil Teaspoon	1. dried basil Gram
sugar Teaspoon	4.2 sugar Gram
parmesan cheese Cup	88 parmesan cheese Gram

WEIGHT RULE FOR WHOLE-ITEM INGREDIENTS

```
wholeItemWeight["onion"] = (1.0 / 3) Pound;
wholeItemWeight["bell pepper"] = 0.5 Pound / 4;
```

```
weightRuleFromQuantifiedWholeItemIngredient[
   Except[_ * _String * _Symbol, (* don't match a triple rule *)
    _?NumberQ * ingredient_ (* do match a pair *)]] :=
  (* generate the following rule *)
  ingredient → ingredient * wholeItemWeight[ingredient];
weightRuleFromQuantifiedWholeItemIngredient[___] = {};
```

WHOLE-ITEM RULES

```
(wholeItemRules = SelectMany[myRecipe, weightRuleFromQuantifiedWholeItemIngredient]) // gridRules
```

```
onion        0.33333 onion Pound
bell pepper  0.125 bell pepper Pound
```

RECIPE WITH EVERYTHING AS A WEIGHT

```
(myRecipe /. volumeRules /. wholeItemRules) // gridRules
```

```
12.713 olive oil Gram
16. zucchini Ounce
19.915 salt Gram
1.5 eggplant Pound
0.33333 onion Pound
0.25 bell pepper Pound
14.5 stewed tomato Ounce
1.05 black pepper Gram
0.5 dried basil Gram
2.1 sugar Gram
12. pasta Ounce
22. parmesan cheese Gram
```

RECIPE IN GRAMS

```
(recipeInGrams =
   Map[Function[ingredient, Convert[ingredient, Gram]], myRecipe /. volumeRules /. wholeItemRules]) // gridRules
```

```
12.713 olive oil Gram
453.59 zucchini Gram
19.915 salt Gram
680.39 eggplant Gram
151.2 onion Gram
113.4 bell pepper Gram
411.07 stewed tomato Gram
1.05 black pepper Gram
0.5 dried basil Gram
2.1 sugar Gram
340.19 pasta Gram
22. parmesan cheese Gram
```

Just for Fun

```
Convert[Apply[Plus, Cases[recipeInGrams, q_ * _String * u_Symbol → q u]], Pound]
```

```
4.8681 Pound
```

atsa lotta pasta -- serves at least six

■ 2. & 3. UNIT-NFLS FOR ALL INGREDIENTS

```
ClearAll[nfls,nflNames]; nflNames={};
```

- Just a constructor that builds a list of NFLs and their names in the background by side-effect

```
createNutritionFactsLabel[name_,
servingSize_,totalCalories_,fatCalories_,
totalFat_,totalFatPercent_,
saturatedFat_,saturatedFatPercent_,transFat_,
cholesterol_,cholesterolPercent_,sodium_,sodiumPercent_,totalCarbohydrates_,totalCarbohydratesPercent_,
dietaryFiber_,dietaryFiberPercent_,
sugars_,protein_,proteinPercent_,
vitaminAPercent_,vitaminCPercent_,calciumPercent_,ironPercent_]:=
(AppendTo[nflNames,name];
nfls[name]={"name"→name,"serving size"→servingSize,"total calories"→totalCalories,"fat calories"→fatCalories,
"total fat"→totalFat,"% daily total fat"→totalFatPercent,"saturated fat"→saturatedFat,"% daily saturated fat"→saturatedFatPercent,"trans fat"→transFat
```

- Now just build up the NFLs for all the ingredients in the recipe by data-mining again:

Olive Oil

```
createNutritionFactsLabel["olive oil", 216 Gram, 1910 Calorie, 1910 Calorie, 216 Gram, 332 Percent, 30 Gram, 149 Percent, 0 Gram,
  0 Gram, 0 Percent, 4 Milli Gram, 0 Percent, 0 Gram, 0 Percent, 0 Gram, 0 Percent, 0 Gram, 0 Gram, 0 Percent,
  0 Percent, 0 Percent, 0 Percent, 7 Percent] // gridRules
```

name	olive oil
serving size	216 Gram
total calories	1910 Calorie
fat calories	1910 Calorie
total fat	216 Gram
% daily total fat	332 Percent
saturated fat	30 Gram
% daily saturated fat	149 Percent
trans fat	0
cholesterol	0
% daily cholesterol	0
sodium	4 Gram Milli
% daily sodium	0
total carbohydrates	0
% daily carbohydrates	0
dietary fiber	0
%daily dietary fiber	0
sugars	0
protein	0
% daily protein	0
vitamin A	0
vitamin C	0
calcium	0
iron	7 Percent

- **Zucchini, summer, with skin, raw**

```
createNutritionFactsLabel["zucchini", 124 Gram, 20 Calorie, 2 Calorie,
  0 Gram, 0 Percent, 0 Gram, 0 Percent, 0 Gram,
  0 Gram, 0 Percent, 12 Milli Gram, 1.0 Percent, 4 Gram, 1.0 Percent, 1.0 Gram, 5 Percent,  2 Gram, 2 Gram, 0 Percent,
  5 Percent, 35 Percent,  2 Percent, 2 Percent] // gridRules
```

name	zucchini
serving size	124 Gram
total calories	20 Calorie
fat calories	2 Calorie
total fat	0
% daily total fat	0
saturated fat	0
% daily saturated fat	0
trans fat	0
cholesterol	0
% daily cholesterol	0
sodium	12 Gram Milli
% daily sodium	1. Percent
total carbohydrates	4 Gram
% daily carbohydrates	1. Percent
dietary fiber	1. Gram
%daily dietary fiber	5 Percent
sugars	2 Gram
protein	2 Gram
% daily protein	0
vitamin A	5 Percent
vitamin C	35 Percent
calcium	2 Percent
iron	2 Percent

Table Salt

```
createNutritionFactsLabel["salt", 1. Cup, 0 Calorie, 0 Calorie,
  0 Gram, 0 Percent, 0 Gram, 0 Percent, 0 Gram,
  0 Gram, 0 Percent, 113 174 Milli Gram, 4716 Percent, 0 Gram, 0 Percent, 0 Gram, 0 Percent,  0 Gram, 0 Gram, 0 Percent,
  0 Percent, 0 Percent, 7 Percent, 5 Percent] // gridRules
```

name	salt
serving size	1. Cup
total calories	0
fat calories	0
total fat	0
% daily total fat	0
saturated fat	0
% daily saturated fat	0
trans fat	0
cholesterol	0
% daily cholesterol	0
sodium	113 174 Gram Milli
% daily sodium	4716 Percent
total carbohydrates	0
% daily carbohydrates	0
dietary fiber	0
%daily dietary fiber	0
sugars	0
protein	0
% daily protein	0
vitamin A	0
vitamin C	0
calcium	7 Percent
iron	5 Percent

Eggplant, raw

```
createNutritionFactsLabel["eggplant", 82 Gram, 20 Calorie, 1.0 Calorie,
  0 Gram, 0 Percent, 0 Gram, 0 Percent, 0 Gram,
  0 Gram, 0 Percent, 2 Milli Gram, 0 Percent, 5 Gram, 2 Percent, 3 Gram, 11 Percent, 2 Gram, 1.0 Gram, 2 Percent,
  0 Percent, 3 Percent, 1.0 Percent, 1.0 Percent] // gridRules
```

name	eggplant
serving size	82 Gram
total calories	20 Calorie
fat calories	1. Calorie
total fat	0
% daily total fat	0
saturated fat	0
% daily saturated fat	0
trans fat	0
cholesterol	0
% daily cholesterol	0
sodium	2 Gram Milli
% daily sodium	0
total carbohydrates	5 Gram
% daily carbohydrates	2 Percent
dietary fiber	3 Gram
%daily dietary fiber	11 Percent
sugars	2 Gram
protein	1. Gram
% daily protein	2 Percent
vitamin A	0
vitamin C	3 Percent
calcium	1. Percent
iron	1. Percent

- **Onion, medium, raw**

```
createNutritionFactsLabel["onion", 160 Gram, 64 Calorie, 1.0 Calorie,
  0 Gram, 0 Percent, 0 Gram, 0 Percent, 0 Gram,
  0 Gram, 0 Percent, 6 Milli Gram, 0 Percent, 15 Gram, 5 Percent, 3 Gram, 11 Percent, 7 Gram, 2.0 Gram, 0 Percent,
  0 Percent, 20 Percent, 4 Percent, 2 Percent] // gridRules
```

name	onion
serving size	160 Gram
total calories	64 Calorie
fat calories	1. Calorie
total fat	0
% daily total fat	0
saturated fat	0
% daily saturated fat	0
trans fat	0
cholesterol	0
% daily cholesterol	0
sodium	6 Gram Milli
% daily sodium	0
total carbohydrates	15 Gram
% daily carbohydrates	5 Percent
dietary fiber	3 Gram
%daily dietary fiber	11 Percent
sugars	7 Gram
protein	2. Gram
% daily protein	0
vitamin A	0
vitamin C	20 Percent
calcium	4 Percent
iron	2 Percent

Bell Pepper, sweet, yellow, raw

```
createNutritionFactsLabel["bell pepper", 186 Gram, 50 Calorie, 3.0 Calorie,
  0 Gram, 1.0 Percent, 0 Gram, 0 Percent, 0 Gram,
  0 Gram, 0 Percent, 4 Milli Gram, 0 Percent, 12 Gram, 4 Percent, 2 Gram, 7 Percent, 2 Gram, 2 Gram, 0 Percent,
  7 Percent, 569 Percent, 2 Percent, 5 Percent] // gridRules
```

name	bell pepper
serving size	186 Gram
total calories	50 Calorie
fat calories	3. Calorie
total fat	0
% daily total fat	1. Percent
saturated fat	0
% daily saturated fat	0
trans fat	0
cholesterol	0
% daily cholesterol	0
sodium	4 Gram Milli
% daily sodium	0
total carbohydrates	12 Gram
% daily carbohydrates	4 Percent
dietary fiber	2 Gram
%daily dietary fiber	7 Percent
sugars	2 Gram
protein	2 Gram
% daily protein	0
vitamin A	7 Percent
vitamin C	569 Percent
calcium	2 Percent
iron	5 Percent

Stewed Tomato

```
createNutritionFactsLabel["stewed tomato", 101 Gram, 80 Calorie, 24.0 Calorie,
  3 Gram, 4 Percent, 1.0 Gram, 3 Percent, 0 Gram,
  0 Gram, 0 Percent, 460 Milli Gram, 19 Percent, 13 Gram, 4 Percent, 2 Gram, 7 Percent, 0 Gram, 2 Gram, 0 Percent,
  13 Percent, 31 Percent, 3 Percent, 6 Percent] // gridRules
```

name	stewed tomato
serving size	101 Gram
total calories	80 Calorie
fat calories	24. Calorie
total fat	3 Gram
% daily total fat	4 Percent
saturated fat	1. Gram
% daily saturated fat	3 Percent
trans fat	0
cholesterol	0
% daily cholesterol	0
sodium	460 Gram Milli
% daily sodium	19 Percent
total carbohydrates	13 Gram
% daily carbohydrates	4 Percent
dietary fiber	2 Gram
%daily dietary fiber	7 Percent
sugars	0
protein	2 Gram
% daily protein	0
vitamin A	13 Percent
vitamin C	31 Percent
calcium	3 Percent
iron	6 Percent

- **Black Pepper (spices, pepper, black)**

```
createNutritionFactsLabel["black pepper", 1. Tablespoon, 16 Calorie, 2 Calorie, 0 Gram, 0 Percent, 0 Gram, 0 Percent, 0 Gram,
  0 Gram, 0 Percent, 3 Milli Gram, 0 Percent, 4 Gram, 1. Percent, 2 Gram, 7 Percent,  0 Gram, 1. Gram, 0 Percent,
  0 Percent, 2 Percent, 3 Percent, 10 Percent] // gridRules
```

name	black pepper
serving size	1. Tablespoon
total calories	16 Calorie
fat calories	2 Calorie
total fat	0
% daily total fat	0
saturated fat	0
% daily saturated fat	0
trans fat	0
cholesterol	0
% daily cholesterol	0
sodium	3 Gram Milli
% daily sodium	0
total carbohydrates	4 Gram
% daily carbohydrates	1. Percent
dietary fiber	2 Gram
%daily dietary fiber	7 Percent
sugars	0
protein	1. Gram
% daily protein	0
vitamin A	0
vitamin C	2 Percent
calcium	3 Percent
iron	10 Percent

Dried Basil (spices, basil, dried)

```
createNutritionFactsLabel["dried basil", 1. Teaspoon, 1.0 Calorie, 0 Calorie, 0 Gram, 0 Percent, 0 Gram, 0 Percent, 0 Gram,
  0 Gram, 0 Percent, 0 Gram, 0 Percent, 0 Gram, 0 Percent,
  0 Gram, 1.0 Percent, 0 Gram, 0 Gram, 0 Percent,
  1.0 Percent, 1.0 Percent, 1.0 Percent, 1.0 Percent] // gridRules
```

name	dried basil
serving size	1. Teaspoon
total calories	1. Calorie
fat calories	0
total fat	0
% daily total fat	0
saturated fat	0
% daily saturated fat	0
trans fat	0
cholesterol	0
% daily cholesterol	0
sodium	0
% daily sodium	0
total carbohydrates	0
% daily carbohydrates	0
dietary fiber	0
%daily dietary fiber	1. Percent
sugars	0
protein	0
% daily protein	0
vitamin A	1. Percent
vitamin C	1. Percent
calcium	1. Percent
iron	1. Percent

- **Sugar (sugars, granulated [sucrose])**

```
createNutritionFactsLabel["sugar", 2 Gram, 11 Calorie, 0 Calorie,
  0 Gram, 0 Percent, 0 Gram, 0 Percent, 0 Gram,
  0 Gram, 0 Percent, 0 Gram, 0 Percent,
  3 Gram, 1.00 Percent, 0 Gram, 0 Percent, 3 Gram,
  0 Gram, 0 Percent,
  0 Percent, 0 Percent, 7 Percent, 5 Percent] // gridRules
```

name	sugar
serving size	2 Gram
total calories	11 Calorie
fat calories	0
total fat	0
% daily total fat	0
saturated fat	0
% daily saturated fat	0
trans fat	0
cholesterol	0
% daily cholesterol	0
sodium	0
% daily sodium	0
total carbohydrates	3 Gram
% daily carbohydrates	1. Percent
dietary fiber	0
%daily dietary fiber	0
sugars	3 Gram
protein	0
% daily protein	0
vitamin A	0
vitamin C	0
calcium	7 Percent
iron	5 Percent

- **Pasta, fresh-refrigerated, plain, as purchased**

```
createNutritionFactsLabel["pasta",
  128 Gram, 369 Calorie, 25 Calorie,
  3 Gram, 5 Percent, 0 Gram, 2 Percent, 0 Gram,
  93 Gram, 31 Percent, 33 Milli Gram, 1.0 Percent,
  70 Gram, 23 Percent, 0 Gram, 0 Percent, 0 Gram,
  14 Gram, 0 Percent,
  1.0 Percent, 0 Percent, 2 Percent, 24 Percent] // gridRules
```

name	pasta
serving size	128 Gram
total calories	369 Calorie
fat calories	25 Calorie
total fat	3 Gram
% daily total fat	5 Percent
saturated fat	0
% daily saturated fat	2 Percent
trans fat	0
cholesterol	93 Gram
% daily cholesterol	31 Percent
sodium	33 Gram Milli
% daily sodium	1. Percent
total carbohydrates	70 Gram
% daily carbohydrates	23 Percent
dietary fiber	0
%daily dietary fiber	0
sugars	0
protein	14 Gram
% daily protein	0
vitamin A	1. Percent
vitamin C	0
calcium	2 Percent
iron	24 Percent

▪ Parmesan Cheese (Cheese, parmesan, grated)

```
createNutritionFactsLabel["parmesan cheese", 100 Gram, 431 Calorie, 251 Calorie, 29 Gram, 44 Percent, 17 Gram, 86 Percent, 0 Gram,
  88 Gram, 29 Percent, 1529 Milli Gram, 64 Percent,
  4 Gram, 1.00 Percent, 0 Gram, 0 Percent, 1 Gram,
  38 Gram, 0 Percent,
  9 Percent, 0 Percent, 111 Percent, 5 Percent] // gridRules
```

name	parmesan cheese
serving size	100 Gram
total calories	431 Calorie
fat calories	251 Calorie
total fat	29 Gram
% daily total fat	44 Percent
saturated fat	17 Gram
% daily saturated fat	86 Percent
trans fat	0
cholesterol	88 Gram
% daily cholesterol	29 Percent
sodium	1529 Gram Milli
% daily sodium	64 Percent
total carbohydrates	4 Gram
% daily carbohydrates	1. Percent
dietary fiber	0
%daily dietary fiber	0
sugars	Gram
protein	38 Gram
% daily protein	0
vitamin A	9 Percent
vitamin C	0
calcium	111 Percent
iron	5 Percent

- **4. & 5. HOW TO ADD UNIT-NFLS**
- **Canonicalize Units**
  - Convert anything compatible with Gram to Gram
  - Convert rules about volumes to rules about weights
    - Another rule that rewrites rules

```
canonicalizeUnits[nfl_] :=
 Map[Function[rule, rule⟦1⟧ → Quiet[N@Convert[rule⟦2⟧, Gram]]],
  (nfl /. {
     (* pattern to match against victim rule *)
     (keyWithVolume_ → (* green arrow is part of victim rule *)

        amount_?NumberQ * volume : (Teaspoon | Tablespoon | Cup | FluidOunce | Pint | Gallon))

      :→ (* pink arrow is part of the rewriting meta-rule *)

      (* this is the resulting new rule with green arrow again *)
      keyWithVolume → amount * volume *
        gramPerTargetVolumeFromDensity[volume, density["name" /. nfl]]})]
```

- ### NORMALIZE, SCALE, ADD

```
nflList = Map[Function[name, nfls[name]], nflNames];
```

```
canonicalizedNfls = canonicalizeUnits /@ nflList;
```

```
norms = ("serving size" / Gram /. # &) /@ canonicalizedNfls
```

```
{216., 124., 273.12, 82., 160., 186., 101., 6.3, 1., 2., 128., 100.}
```

- **This is vector scale!**

```
scaleNfl[nfl_, scalar_] :=
 Map[Function[line, If[line⟦1⟧ === "name",
    line, (* skip the name line *)
    line⟦1⟧ → line⟦2⟧ * scalar]], nfl]
```

```
normalizedNfls = MapThread[scaleNfl, {canonicalizedNfls, 1 / norms}];
```

```
scaledNfls = MapThread[scaleNfl, {normalizedNfls, recipeInGrams / Gram / nflNames}];
```

- **This is vector sum!**

```
sumNfls[nfl1_, nfl2_] :=
 MapThread[Function[{line1, line2},
   If[line1⟦1⟧ === line2⟦1⟧, (* don't add up dimensions that don't match *)
    line1⟦1⟧ → (line1⟦2⟧ + line2⟦2⟧) // Chop,
    Throw["foo"]]],  {nfl1, nfl2}]
```

FINAL RECIPE, FEEDING SIX

```
scaleNfl[Fold[sumNfls, First[scaledNfls], Rest[scaledNfls]], 1 / 6] // gridRules
```

name	bell pepper + black pepper + dried basil + eggplant + olive oil + onion + parmesan cheese + pasta + salt + stewed tomato + sugar + zucchini
serving size	368.02 Gram
total calories	309.72 Calorie
fat calories	58.413 Calorie
total fat	6.546 Gram
% daily total fat	9.8998 Percent
saturated fat	1.5959 Gram
% daily saturated fat	7.5358 Percent
trans fat	0
cholesterol	44.422 Gram
% daily cholesterol	14.795 Percent
sodium	1.7696 Gram
% daily sodium	73.6 Percent
total carbohydrates	53.543 Gram
% daily carbohydrates	17.71 Percent
dietary fiber	6.8463 Gram
%daily dietary fiber	25.73 Percent
sugars	5.8525 Gram
protein	12.1 Gram
% daily protein	2.7658 Percent
vitamin A	13.434 Percent
vitamin C	107.62 Percent
calcium	11.903 Percent
iron	19.675 Percent