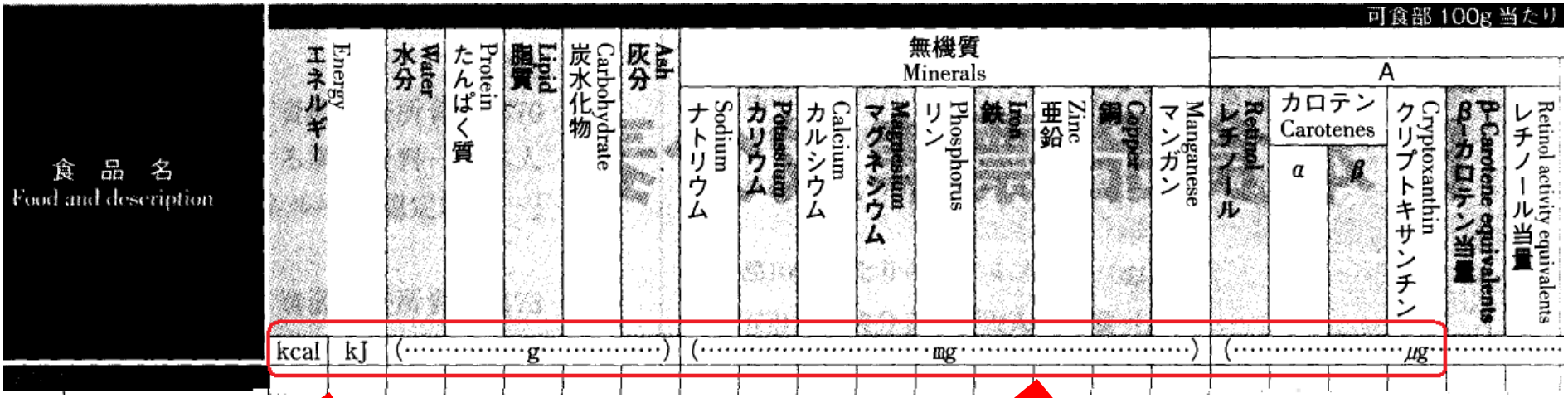
# The International System of Units (SI)

Standard Tables of Food Composition in Japan



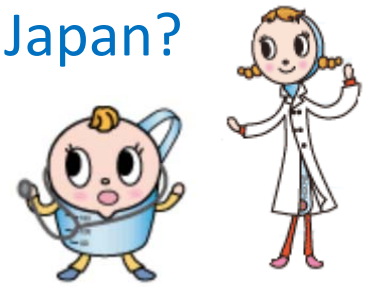
| 食品名 Food and description | 可食部 100g 当たり | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | エネルギー Energy | | 水分 Water | たんぱく質 Protein | 脂質 Lipid | 炭水化物 Carbohydrate | 灰分 Ash | 無機質 Minerals | | | | | | | | | | | A | | | | |
| | | | | | | | | ナトリウム Sodium | カリウム Potassium | カルシウム Calcium | マグネシウム Magnesium | リン Phosphorus | 鉄 Iron | 亜鉛 Zinc | 銅 Copper | マンガン Manganese | レチノール Retinol | カロテン Carotenes | | クリプトキサンチン Cryptoxanthin | β-カロテン当量 β-Carotene equivalents | レチノール当量 Retinol activity equivalents |
| | | | | | | | | | | | | | | | | | | α | β | | | |
| | kcal | kJ | (g) | | | | | (mg) | | | | | | | | | (μg) | | | | | | |

1. What is unit?

2. Do you know k, m and μ?

3. Why “kJ” is listed with “kcal”
at Standard Tables of Food Composition in Japan?

4. Relation between idea of SI
and the unit with spoon or cup by Aya.



# 1. What is “unit” ?

*1）Let us start from* ***what is “unit”?***

**Quantity = numerical value × unit**

Examples) length ･･･ 5m Here “m” is metre, unit of length.
weight ･･･ 200g Here “g” is gram,unit of weight.
time ･･･ 60s or 15min Here “s” is second and “min” is minute,unit of time

## *2）combination of unit*

Quality like area,volume,speed(velocity) is expressed by combination of unit

Examples) area ･･･$10m^2$
the area of rectangular which has two meters long and three meter wide is given by $2m \times 3m = 6m^2$.

speed ･･･2m/s where m/s is abbreviation of $\frac{m}{s}$ and means that 2m per 1s.

## *3）calculation of quantity* ***=>please calculate with unit simply***

Examples) 100g+300g=400g 100m÷25s=4.0m/s

# 2.Do you know k, m and μ?

1)k(kilo) is familiar as kg (kilo gram) and km(kilo metre)
where 1kg=1,000g and 1km=1,000m

Prefix is placed in front of any unit.

2)Other prefix

| Prefix | name | multiple | Prefix | name | multiple |
|---|---|---|---|---|---|
| **k** | **kilo** | 1,000 | **m** | **mili** | $\frac{1}{1{,}000}$ |
| M | mega | 1,000,000 | **μ** | **micro** | $\frac{1}{1{,}000{,}000}$ |
| G | giga | 1,000,000,000 | n | nano | $\frac{1}{1{,}000{,}000{,}000}$ |
| T | tega | 1,000,000,000,000 | p | pico | $\frac{1}{1{,}000{,}000{,}000{,}000}$ |

Pay attention to **three**”0” and “,” ! Why three 0?

# Let us see large digit numbers

for understanding of prefixes in unit.

**Questions about Hindu-Arabic numerals;**

**Q1** Which is easier to see how many digit have? 1000000000000000000 or 100,000,000,000,000,000

From this Q1, you may understand why "," is included at large digit number.

Table1

| 日本 | Hindu-Arabic numerals | English |
|---|---|---|
| 一 | 1 | one |
| 十 | 10 | ten |
| 百 | 100 | a hundred |
| 千 | 1,000 | a thousand |
| 万 | 10,000 | ten thousand |
| 十万 | 100,000 | a hundred thousand |
| 百万 | 1,000,000 | a million |
| 千万 | 10,000,000 | (  ) million |
| 一億 | 100,000,000 | (  ) million |
| 十億 | 1,000,000,000 | a billion |
| 百億 | 10,000,000,000 | (  ) |
| 千億 | 100,000,000,000 | (  ) |
| 一兆 | 1,000,000,000,000 | a trillion |
| 十兆 | 10,000,000,000,000 | (  ) |
| 百兆 | 100,000,000,000,000 | (  ) |
| 千兆 | 1,000,000,000,000,000 | a quadrillion |
| 一京 | 10,000,000,000,000,000 | (  ) |
| 十京 | 100,000,000,000,000,000 | (  ) |

**Q2 Please insert appropriate number into blank(  ) in the next sentence.**

"," is added for each (  ) digit at the Hindu-Arabic numerals.

=>Please remember this answer !

**Questions about English word to express the large digit number;**

**Q3 Please insert appropriate number into blank(  )in the following and at table1.**

Hint; 10,000=10×1,000 so 10,000 is called ten thousand.

100,000=100×1,000

so 100,000 is called a hundred thousand.

Therefore

10,000,000=(  )×1,000,000 and called (  ) million

And 100,000,000=(  )×1,000,000 and called (  ) million

And so on.

# Answer for large digit numbers

**A1** 100,000,000,000,000,000 is easier than 10000000000000000 to see how many digit have.

**A2** "," is added for each ( **3** ) digit at the Hindu-Arabic numerals.

| 日本 | Hindu-Arabic numerals | English |
|---|---|---|
| 一 | 1 | one |
| 十 | 10 | ten |
| 百 | 100 | a hundred |
| 千 | 1,000 | a thousand |
| 万 | 10,000 | ten thousand |
| 十万 | 100,000 | a hundred thousand |
| 百万 | 1,000,000 | a million |
| 千万 | 10,000,000 | ( **ten** ) million |
| 一億 | 100,000,000 | (**a hundred** ) million |
| 十億 | 1,000,000,000 | a billion |
| 百億 | 10,000,000,000 | ( **ten billion** ) |
| 千億 | 100,000,000,000 | ( **a hundred billion** ) |
| 一兆 | 1,000,000,000,000 | a trillion |
| 十兆 | 10,000,000,000,000 | ( **ten trillion** ) |
| 百兆 | 100,000,000,000,000 | (**a hundred trillion** ) |
| 千兆 | 1,000,000,000,000,000 | a quadrillion |
| 一京 | 10,000,000,000,000,000 | ( **ten quadrillion** ) |
| 十京 | 100,000,000,000,000,000 | (**a hundred quadrillion**) |

## Why each **3** digit?

Because large digit numbers are expressed as a ○, **ten** ○ and **a hundred** ○ in English.

Here ○ is thousand,million,billion,trillion or quadrillion and so on.

This affects → Prefix for unit

| Prefix | name | multiple | English |
|---|---|---|---|
| k | kilo | 1,000 | thousand |
| M | mega | 1,000,000 | million |
| G | giga | 1,000,000,000 | billion |
| T | tega | 1,000,000,000,000 | trillion |

# Seven base units of the SI


| | | |
|---|---|---|
| metre | m | Unit of length |
| kilogram | kg | Unit of mass |
| second | s | Unit of time |
| ampere | A | Unit of electric current |
| kelvin | K | Unit of thermodynamic temperature |
| mole | mol | Unit of amount of substance |
| candela | cd | Unit of luminous intensity |

Any (physical) quantity can be expressed
by the combination of these seven base units with prefix.

Examples) unit of speed =>m/s unit of volume=>$m^3$ unit of density=> $kg/m^3$
unit of force=>$kg \cdot m/s^2$ unit of energy=>$kg \cdot m^2/s^2$ and so on

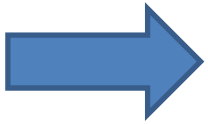
You can see the definition of m,kg,s,A,K,mol,cd at http://www.bipm.org/en/si/base_units/.
But need not worry about these complicated definitions.

# Unit of energy

Point: The principle of the conservation of *energy*

This law is right between several type of energy, that is,
kinetic energy, potential energy, electric energy, atomic energy ,
chemical energy, thermal energy and so on.

<u>They can change into different types of energy</u>.



every type of *energy can be expressed by the same unit*.

$E=mc^2$ atomic energy; famous Einstein's law
where "m" means mass and "c" means speed of light.

$E=\frac{1}{2}mv^2$ kinetic energy
where "m" means mass and "v" means speed.

$E=mgh$ potential energy
where "g" means acceleration of gravitation and "h" means height.

# Unit of energy is $kg \cdot m^2/s^2$

Calculation:

unit of energy =unit of mass ×（unit of speed)$^2$

$=kg \cdot (m/s)^2 = kg \cdot m^2/s^2$

or

$E=mc^2$ or $E=\frac{1}{2}mv^2$

unit of energy =unit of mass

× unit of acceleration × unit of length

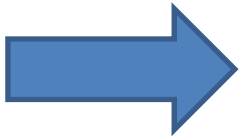
$=kg \cdot m/s^2 \cdot m = kg \cdot m^2/s^2$

$E=mgh$

where acceleration means change of speed per time(second),
so unit of accelaeration=(m/s)/s=m/s$^2$

Unit of energy is $kg \cdot m^2/s^2$=J[joule]

$kg \cdot m^2/s^2$ is so complicted that
it is defined as J[joule].



This J[joule] with prefix **k**(=1,000)

is listed at *Standard Tables of Food Composition in Japan*.

cal(calorie) cannot be listed alone,
and must be listed with joule.

Why?

# Why cal(calorie) must be listed with joule?

- Definition of 1 calorie (1cal)

energy needed to raise the temperature of 1g of ***water*** by 1℃.

Uncertainty!

Depend on the atmospheric pressure and the starting temperature

| | |
|---|---|
| From 3.5℃ to 4.5℃ | ≈4.204J |
| From 14.5℃ to 15.5℃ | ≈4.1855J |
| From 19.5℃ to 20.5℃ | ≈4.182J |
| From 0℃ to 100℃ | ≈4.190J ×100 |

Value of Air free water at standard atmospheric pressure

kcal given by 4.184kJ is listed with kJ

at Standard Tables of Food Composition in Japan

# To further reduce uncertainty

*with all the accuracy and reliability*
*which the present state of science permits*

Change of the definition of m(metre) makes uncertainty much smaller.

1791 Beginning of m(metre) ***Influence of French Revolution***

1m= 1/10,000,000 of the distance between the North Pole and the Equator

→ **Relative uncertainty $10^{-4}$**

1889 Distance between precision marks on a new 'X' shaped 90% platinum 10% iridium bar at 0℃

→ **Relative uncertainty $10^{-7}$**

1960

1m= 1650763.73 times the wavelength radiation emitted by the krypton-86 isotope.

→ **Relative uncertainty $4 \times 10^{-9}$**

1983

1m= Length of the path travelled by light in a vacuum in 1/299,792,458 of a secod.

→ **Relative uncertainty $10^{-10}$**

# Aya wanted to reduce uncertainty by *devising measuring cup* and *spoons*

= Recipe =

How to prepare and cook them,
what seasonings to add,
and exactly what quantities of each item to put in.

=Before=

By intuition or experience of chef (料理人の感・経験 ),
**only** chef can cook that meal.

=After=

By recipe, measuring cup and spoons ,
**Every one** can cook that meal.

A kind of revolution

How do you think about
the International System of Units (SI)?