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Lecture 04 Anthropometries and Ergonomics

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4. Anthropometries and Ergonomics

In the behavior setting, the **milieu** is expected to meet with the **human needs**.

The **built environment**, on the other hand, is expected to provide **body comfort**.

Anthropometries and ergonomics are two sciences that deals with the relationship between human capacities and the built environment.

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4.1 Anthropometry

Anthropometry is the **science** that studies on **human physical dimensions**, **capabilities**, and **limitations**.

The term is originated from Greek:

anthropos + metron

“human” **"measure"**

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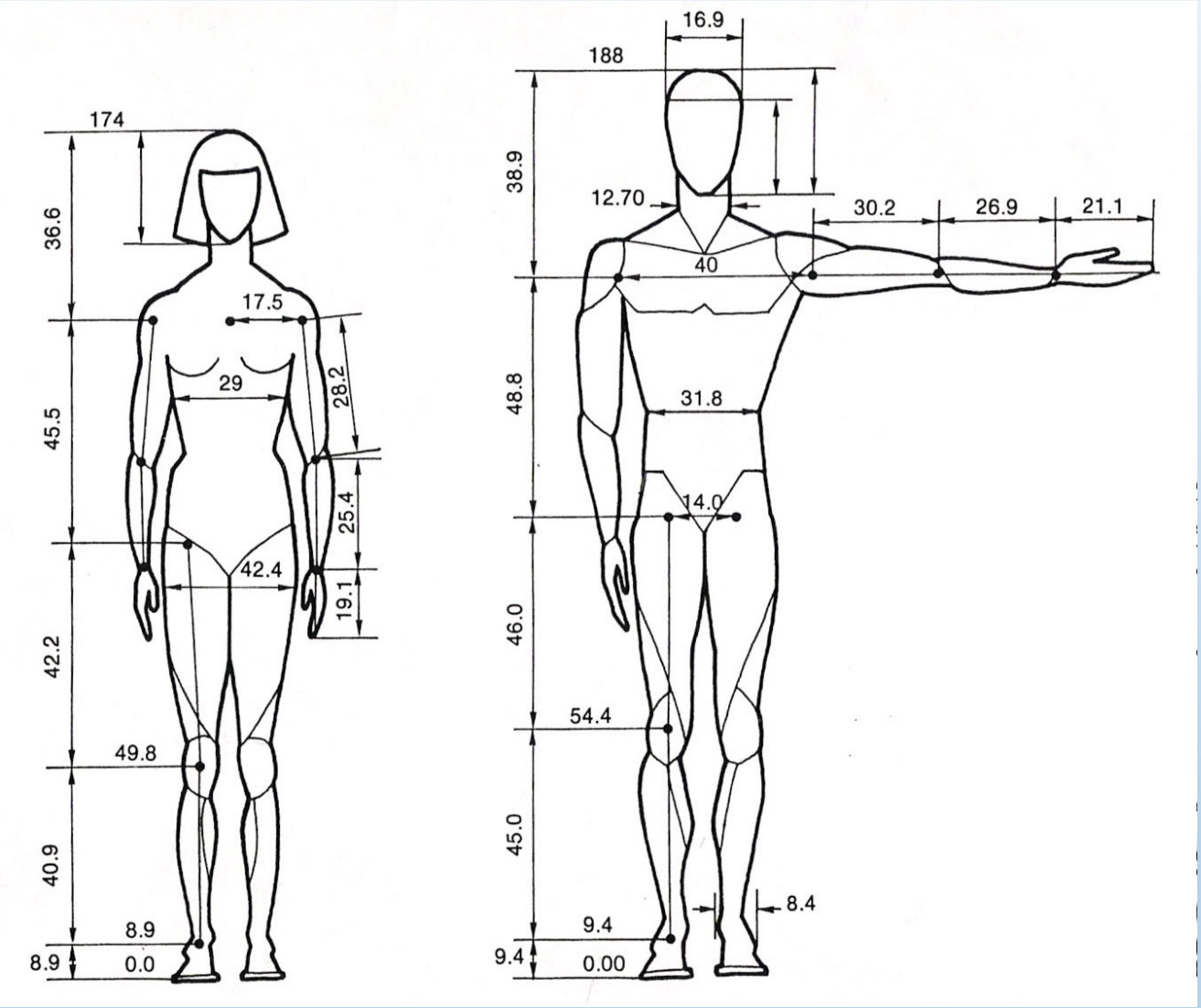
4.1 Anthropometry

For the environment and behavior fit, it must be remembered that the **physiological** **capabilities of people differ from each other**.

From infancy to adulthood and elderly, physiological capabilities changes all the time.

Physiological capabilities also vary by gender and race.

4.1 Anthropometry



Source: Source: http://pre08.deviantart.net/3062/th/pre/i/2005/348/9/c/human_proportions_by_bents_stock.jpg

Human physical dimensions, capabilities, and limitations vary by gender.

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4.1 Anthropometry

The *statistical sizes* vary with age the average height for an elderly person would be up to 80mm lower than that for a younger person

Human physical dimensions, capabilities, and limitations vary by age

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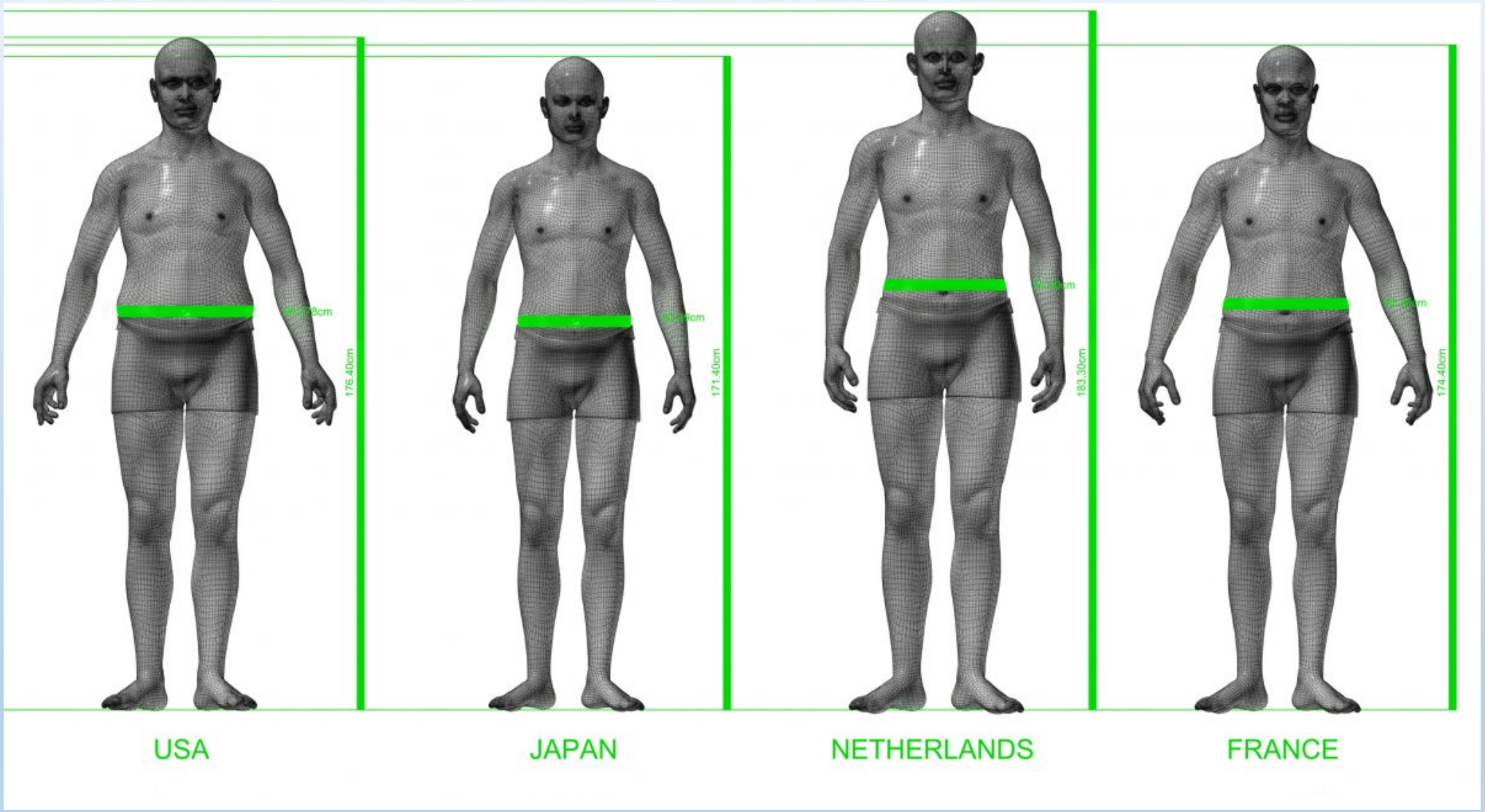
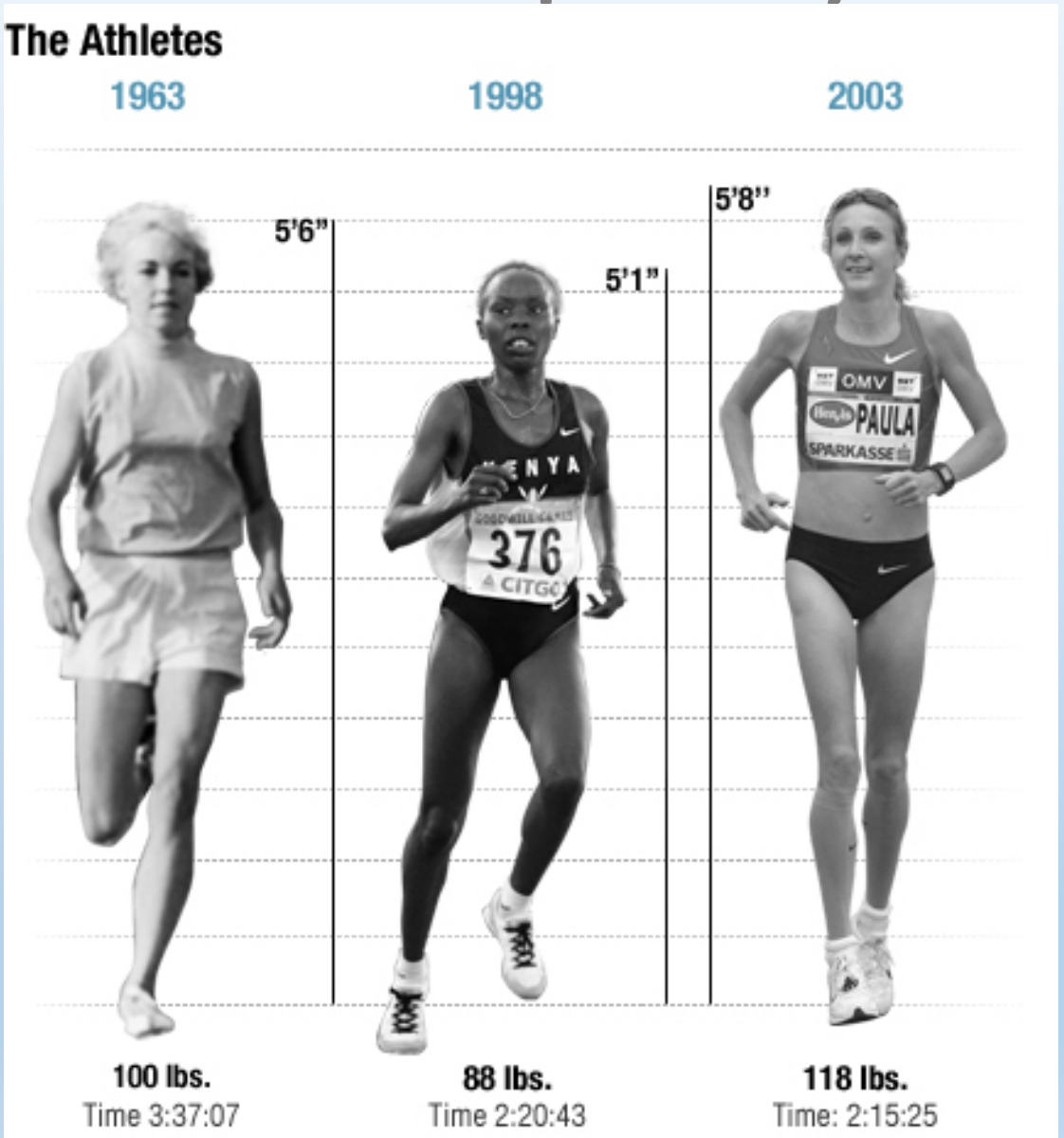
4.1 Anthropometry



Source: http://static2.businessinsider.com/image/52448f9b6bb3f7de014a8db7-1200-667/country-measurements.jpg

Human physical dimensions, capabilities, and limitations vary by race

4.1 Anthropometry



Source: http://naturallyengineeredcom-files.s3.amazonaws.com/blog/wp-content/uploads/2012/08/olympic-marathon-body-infographic.jpg

Human physical dimensions, capabilities, and limitations vary by profession.

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4.1 Anthropometry

- The science of anthropometrics uses data on human dimensions and ranges of **motion** (how far various body parts can move).
- Researchers usually measure subjects from a particular group (older, adult ,females), then calculate the **averages**.
- They also study **differences** between groups (e.g., comparing young women to very old ones)

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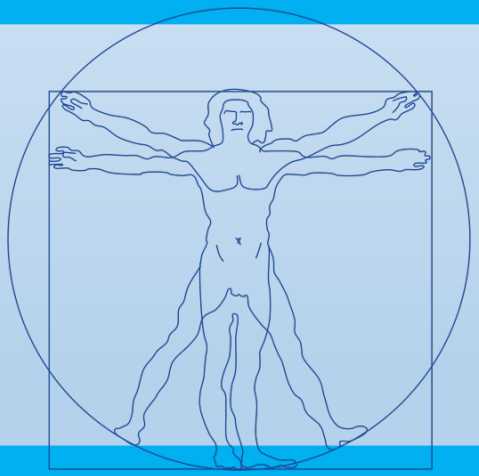
4.1 Anthropometry

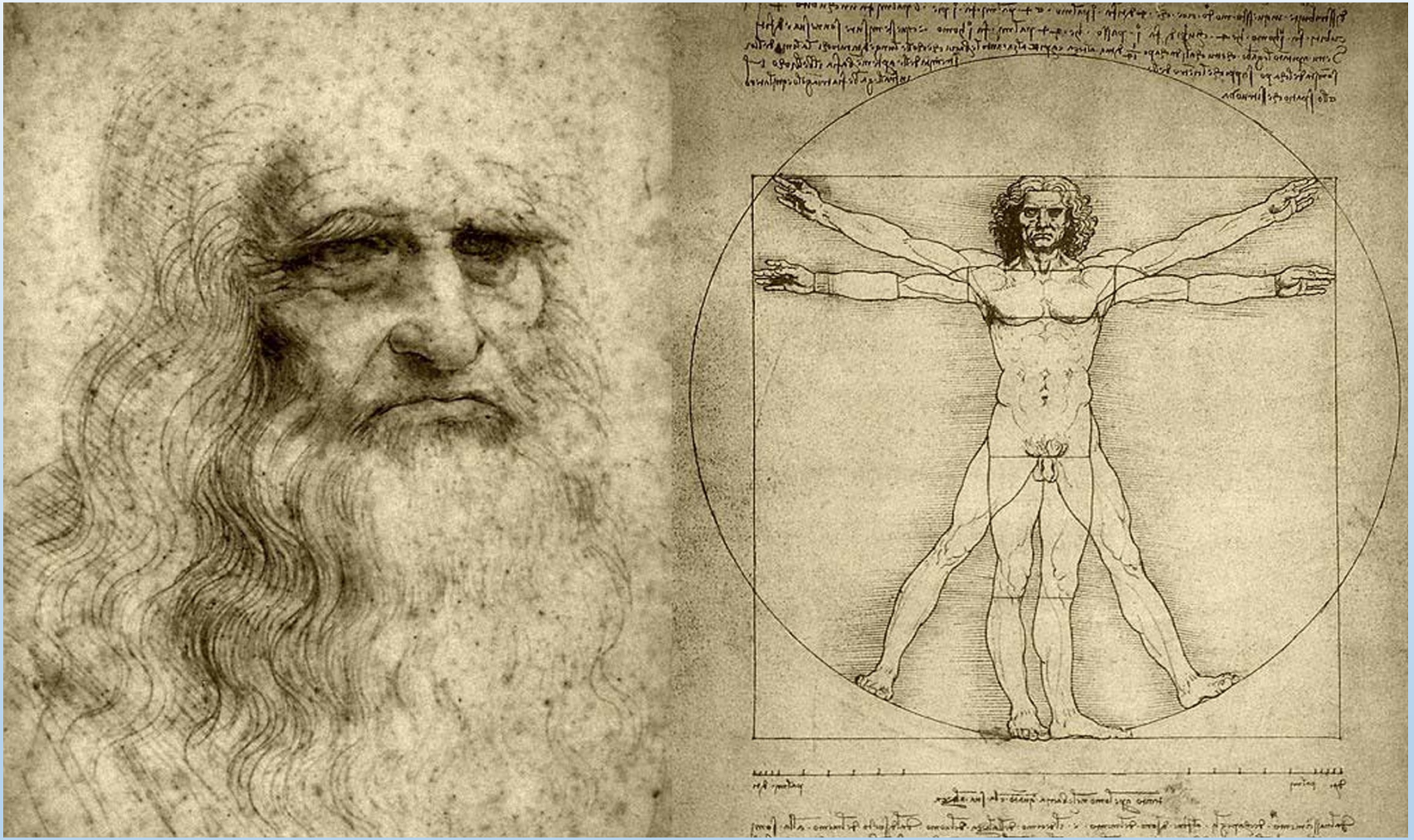
There are two basic types of human body dimensions:

Structural (static) → Include measurements of head, torso, and limbs in standard positions.



Functional (dynamic) → Measurements taken in working positions or during movements associated with certain tasks.

4.1.1 History of Anthropometry Studies



Source: https://bedanktvoordevis.files.wordpress.com/2015/06/leonardo-da-vinci-vitruvian-man.jpg

The Vitruvian man by **Leonardo da Vinci is the earliest examples of anthropometry studies.**

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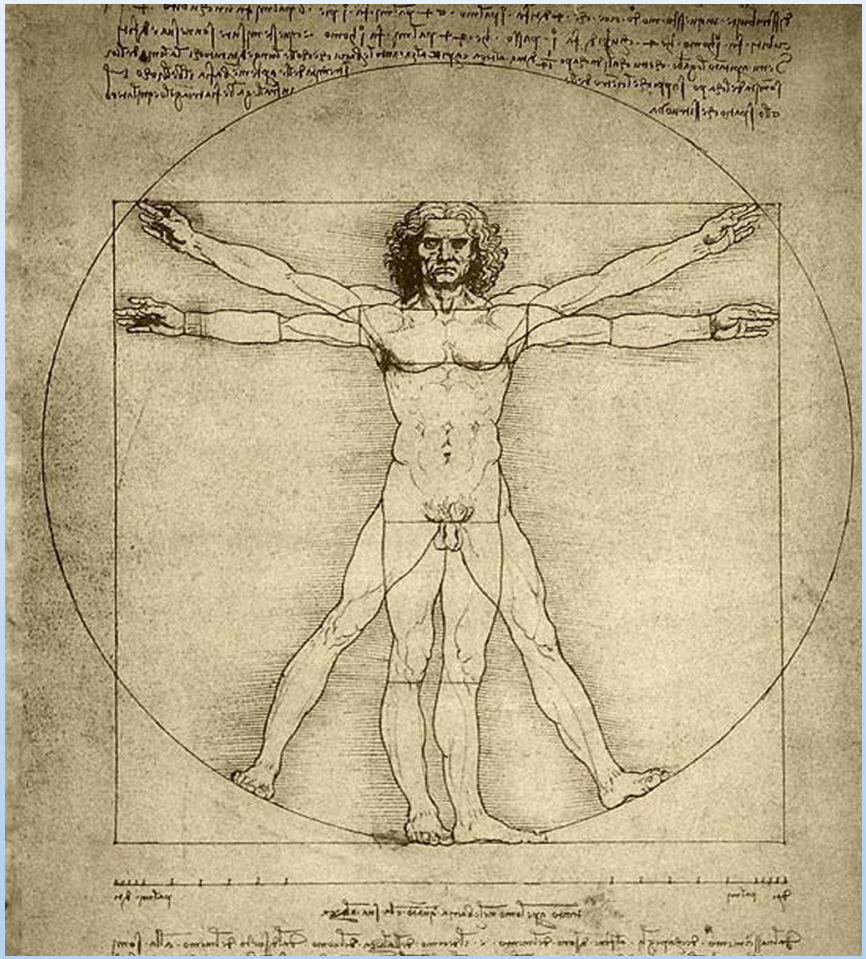
4.1 Anthropometry



Source:
https://bedanktvoordevis.files.wordpress.com/2015/06/leonardo-da-vinci-vitruvian-man.jpg

The *Vitruvian Man* is translated from Italian to English as "The proportions of the human body according to Vitruvius".

Vitruvius was a Roman architect (and author, civil & military engineer) who discussed about perfect proportion in architecture.

Vitruvius's studies influenced Da vinci to discover the rules of proportions between the parts of the human body.

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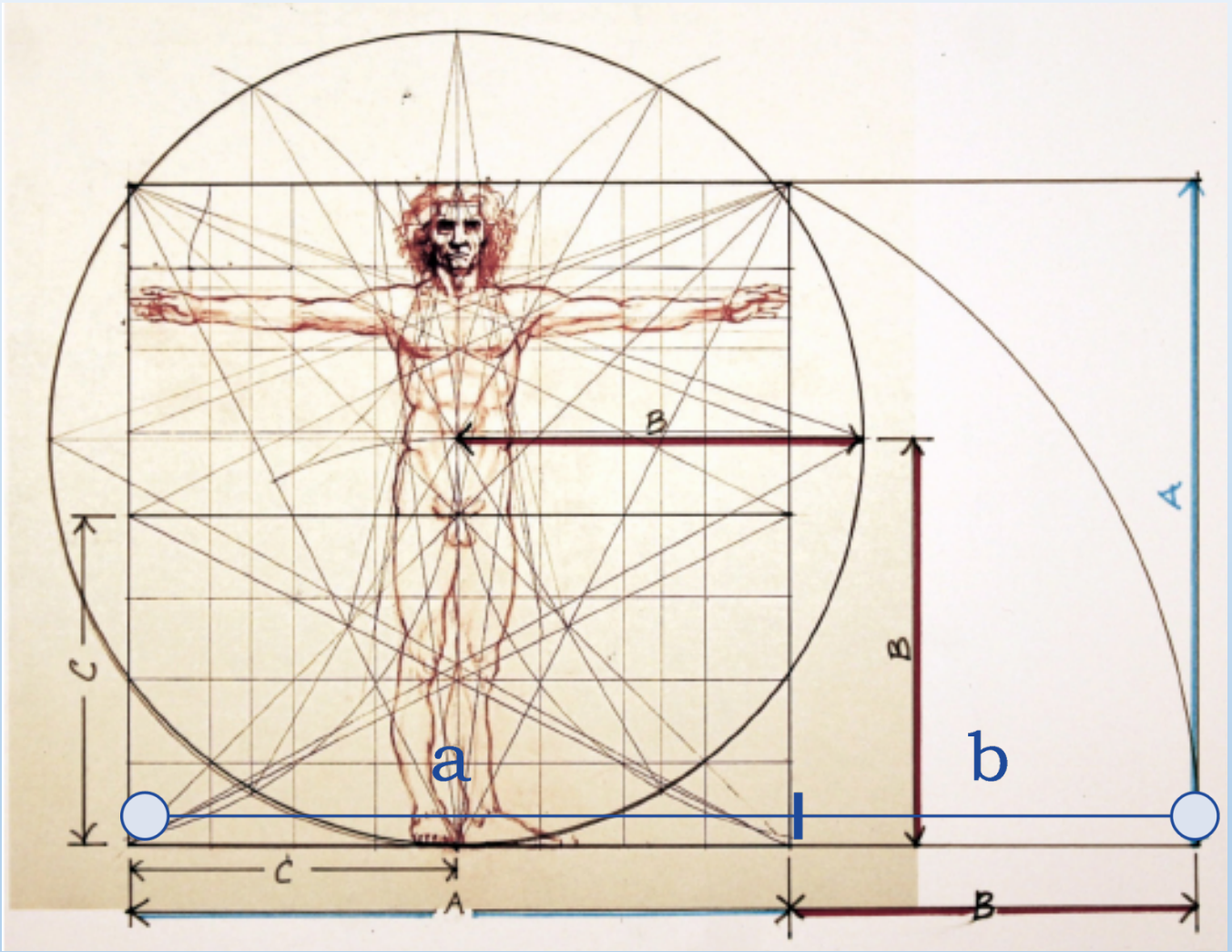
4.1.1 History of Anthropometry Studies



$$\frac{a+b}{a} = \frac{a}{b} \sim 1.618$$

Source: researchgate.net

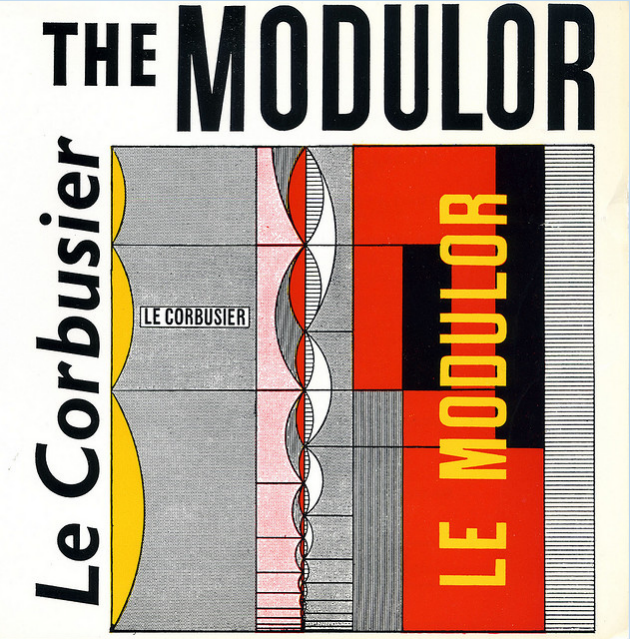
Da Vinci believed that the ideal human proportions were determined by the harmonious proportions that he believed governed the universe

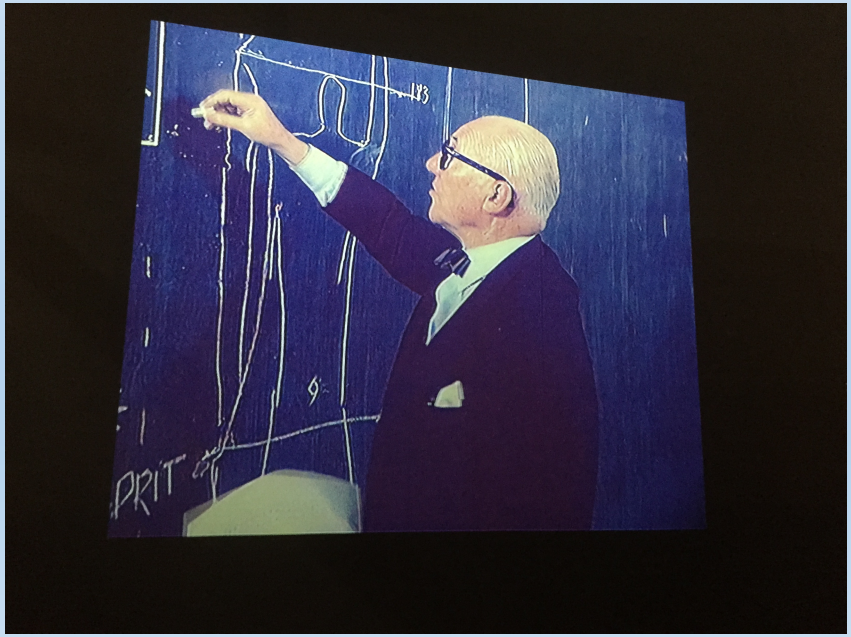
To him, the ideal man would fit cleanly into a circle as depicted in his famed drawing of Vitruvian man.

4.1.1 History of Anthropometry Studies

Like Da vinci, Le Corbusier also searched for harmonic proportions of human body that were an appropriate means of design.

He dedicates a whole chapter in his book named '**Vers une architecture**' to the theme of regulating lines and observed in his arguments prefacing this.



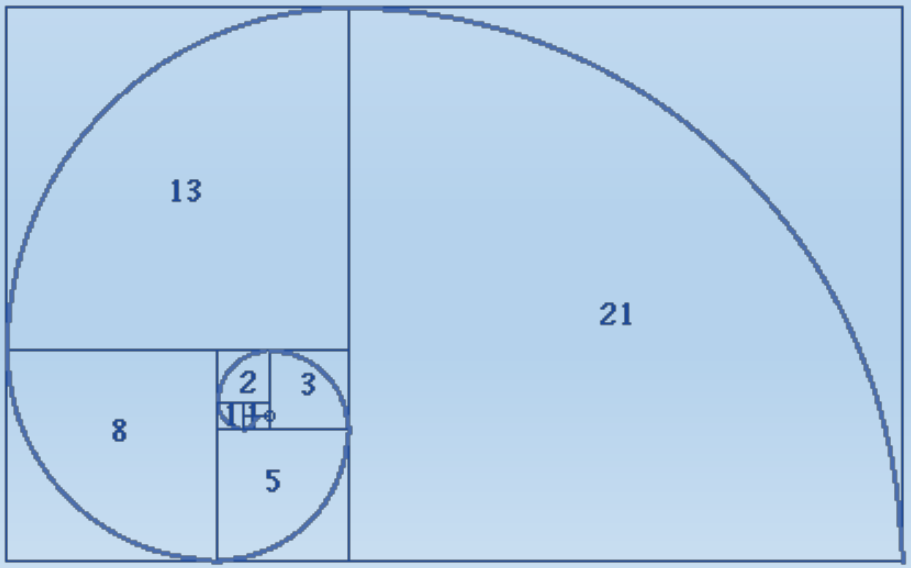


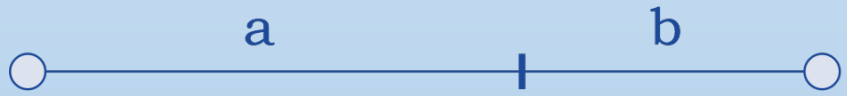
Source: http://www.exhibitioncritique.com/wp-content/uploads/2015/06/IMG_3317.jpg

4.1.1 History of Anthropometry Studies

- The Modulor was based on the **Golden Section** and on the measurements of the human body.

Golden section (a figure in which the relationship of the smaller part to the larger part is the same as that between the larger part and the whole)

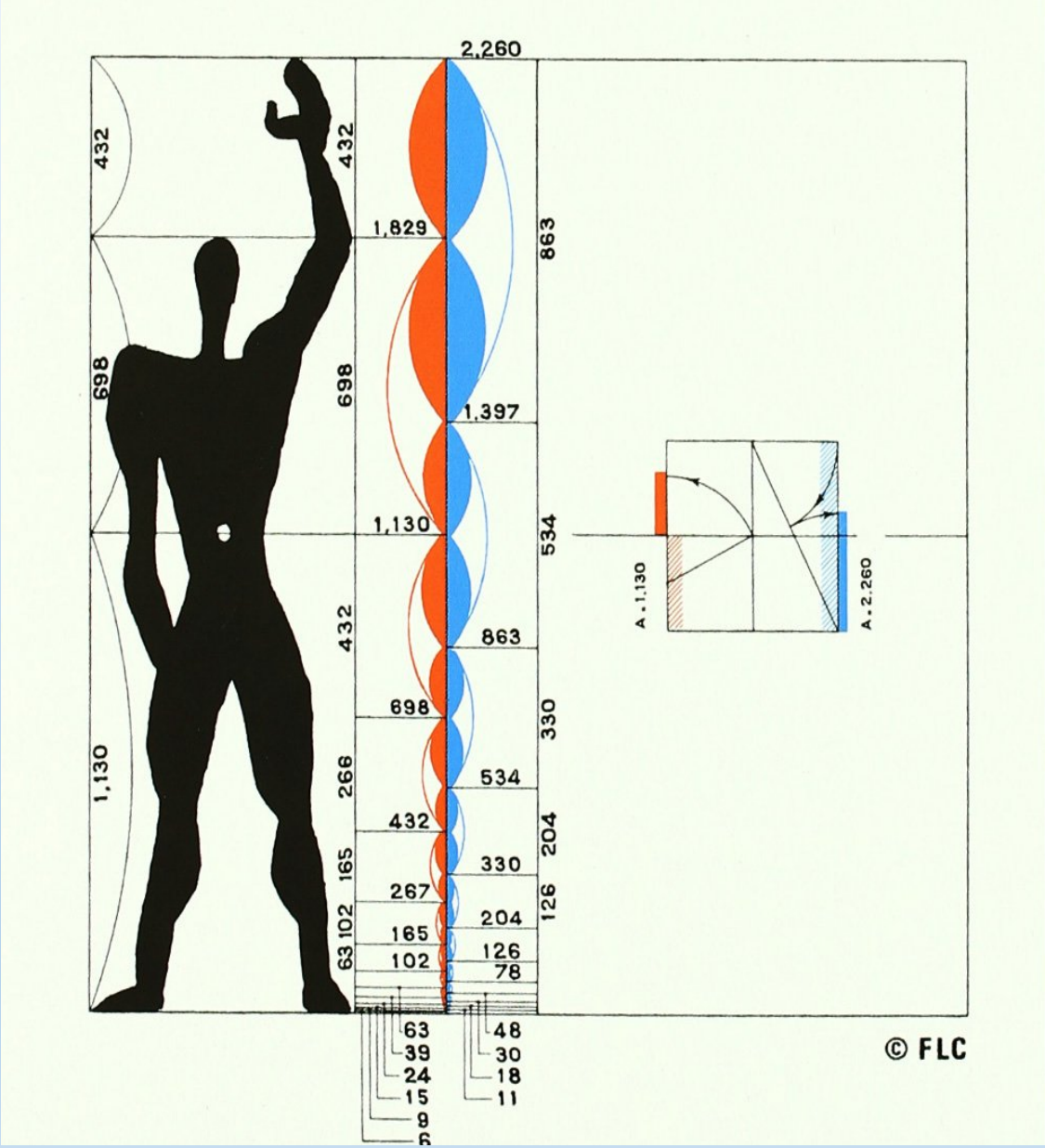




$$\frac{a+b}{a} = \frac{a}{b} \sim 1.618$$

Source: http://nmsmithphotoshop1.weebly.com/uploads/9/5/2/7/9527067/4094733_orig.gif

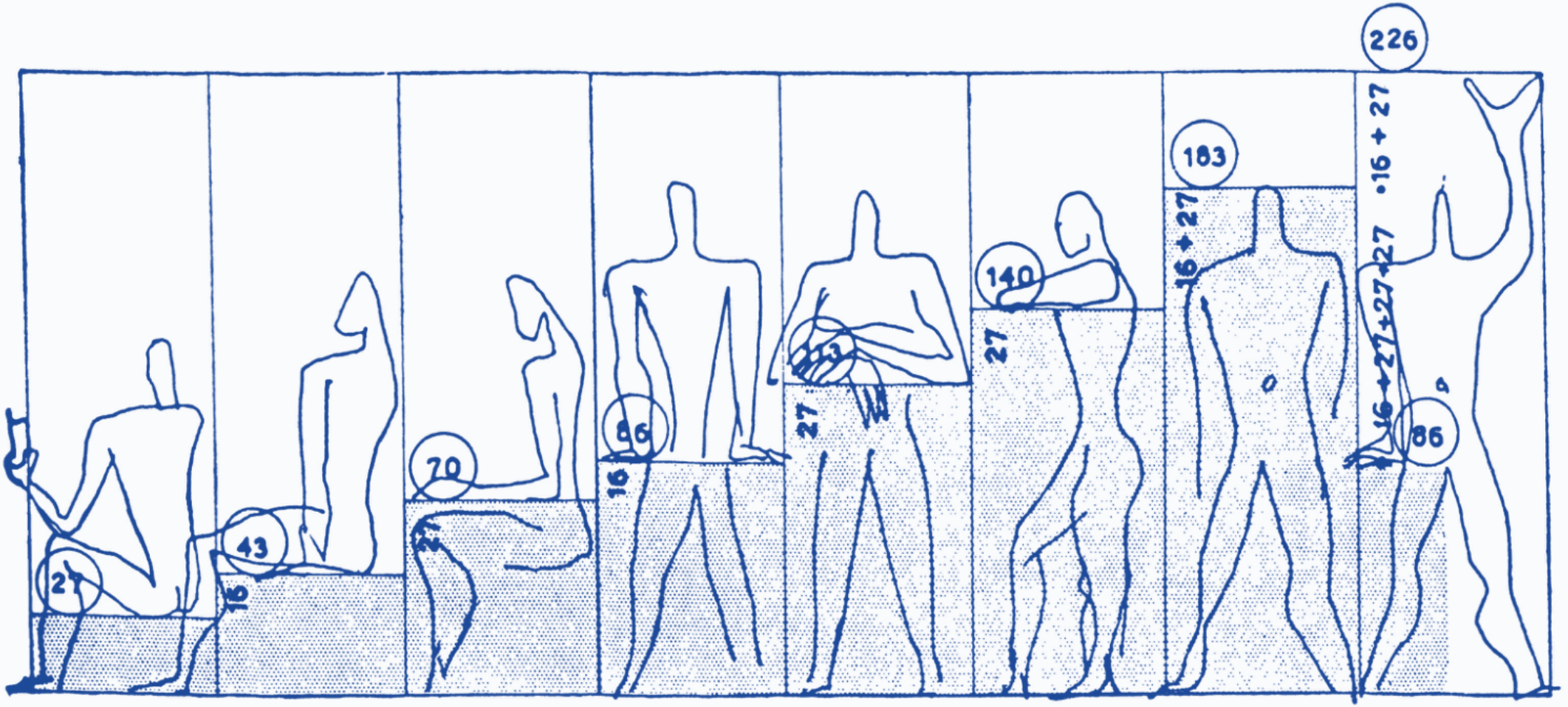
4.1.1 History of Anthropometry Studies



Le Corbusier took a person 6 feet (1.83 m) tall as his norm, the height of the navel being 1.13 m and that of the outstretched hand 2.26 m above the ground.

Source: https://images-na.ssl-images-amazon.com/images/I/61L1n6-FZ%2BL.jpg

4.1.1 History of Anthropometry Studies

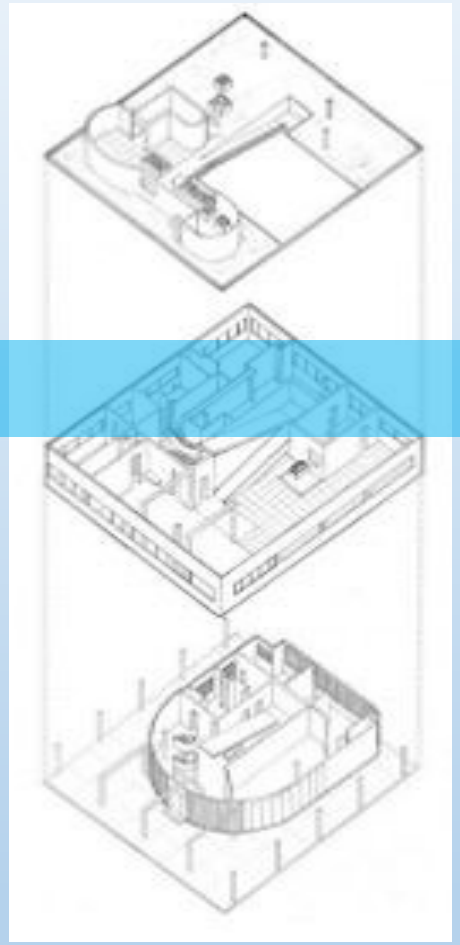


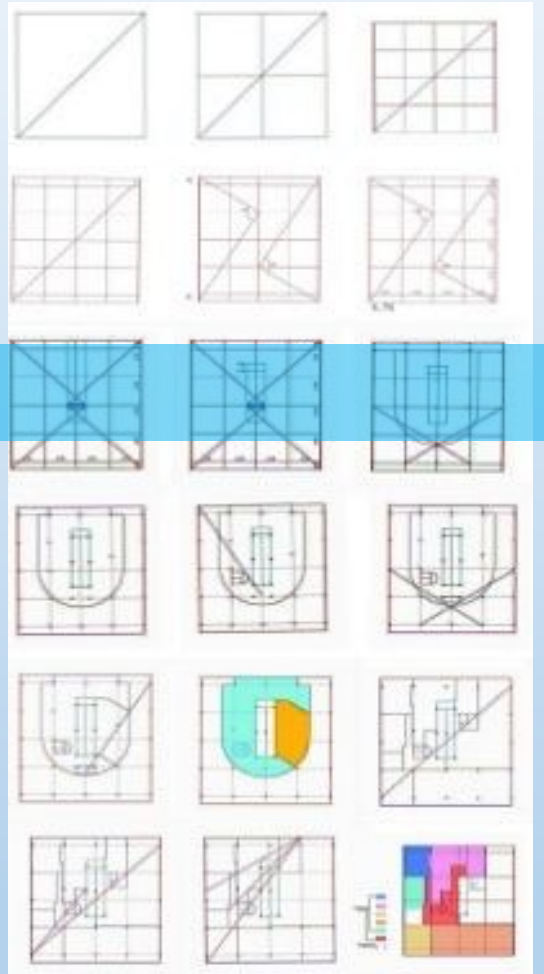
Source: http://miguelmartindesign.com/blog/wp-content/uploads/2011/01/figure13.jpg

Le Corbusier developed many standards based on his studies on human proportions.

4.1.1 History of Anthropometry Studies

Le Corbusier‘sVilla Savoye





Source: https://s-media-cache-ak0.pinimg.com/736x/09/e1/92/09e192e6661714293b9b97522b6d17c2.jpg & Pinterest

Le Corbusier put the concept of Golden Section in the facades using baseline of 12 degrees to determine the rule of dividing the main part + the central ramp/ windows/ roadway.

4.1.1 History of Anthropometry Studies

Source: Wikipedia

Use of Golden Section in the facades at Le Corbusier's Unité d'habitation

4.1.2 Capabilities of Human Body

As mentioned earlier anthropometry deals with **human physical dimensions**, **capabilities**, and **limitations**.

Human metabolism also have **capabilities for bodily heat** exchanges with the environment.

Comfortable temperature for an individual depends on that person's activity and clothing and on the characteristics of the person involved.

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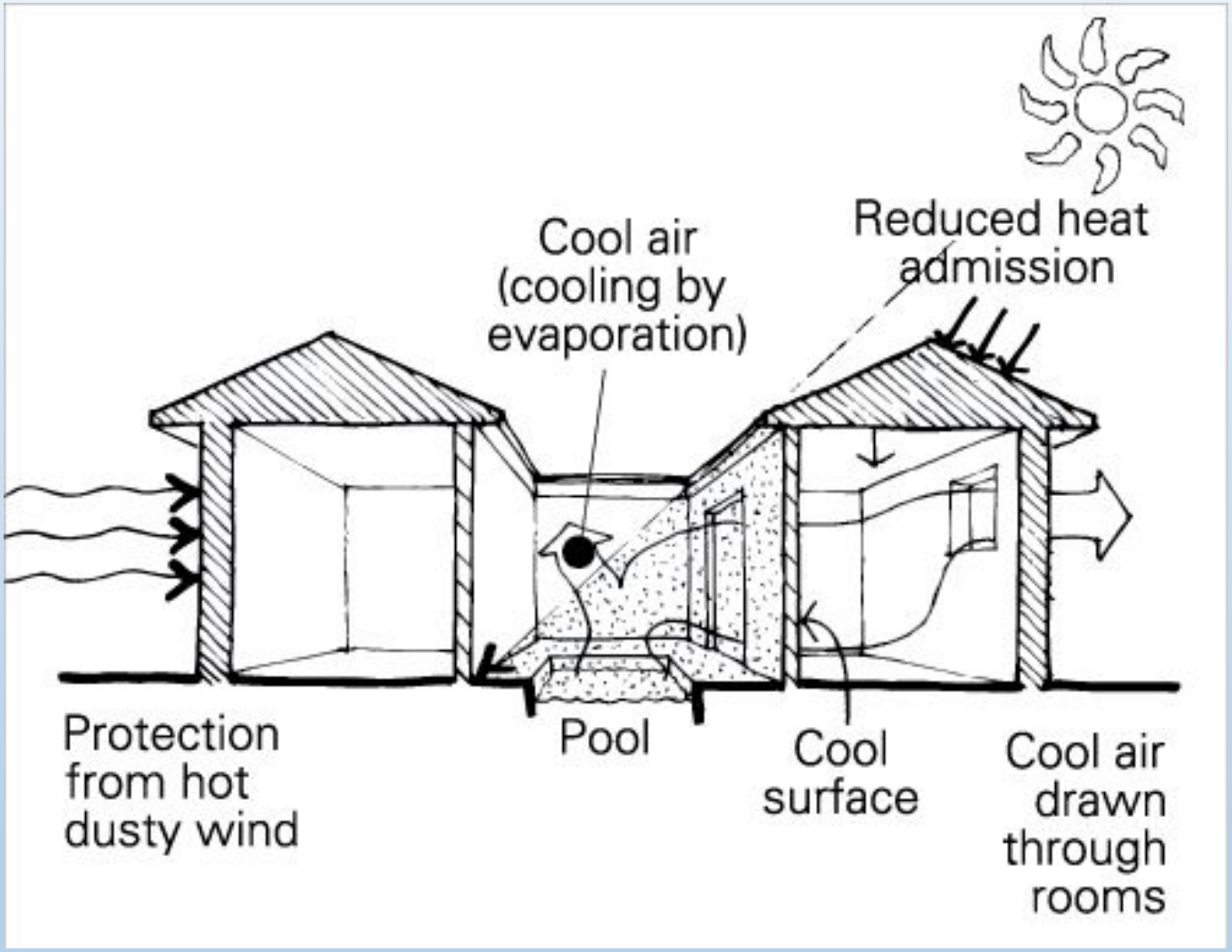
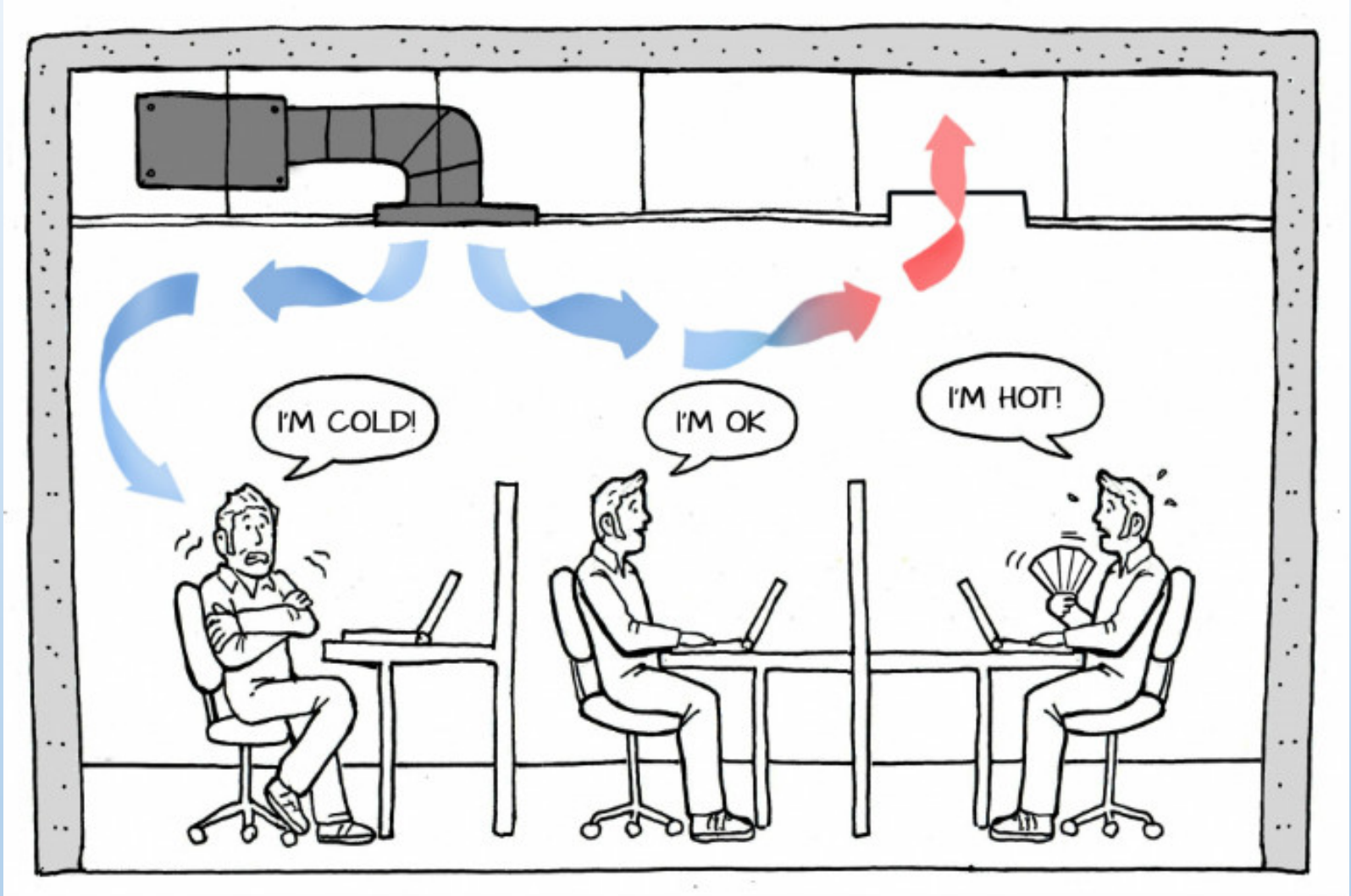
4.1.2.1 Thermal Comfort



Source: https://s-media-cache-ak0.pinimg.com/736x/2d/cc/75/2dcc7545583dd1a90ad8ef4dae7106a2.jpg

Thermal comfort can be provided in an indoor environment by the orientation of the building, location of the openings as natural ventilation.

4.1.2.1 Thermal Comfort



Source: https://s-media-cache-ak0.pinimg.com/originals/9f/ac/4e/9fac4ed4a594198a8e43b29d053fbf4a.jpg

With the technology, thermal comfort can be artificially provided in an indoor environment; but perceptions of comfort not only depend on the air temperature but on the air flow and location of opening.

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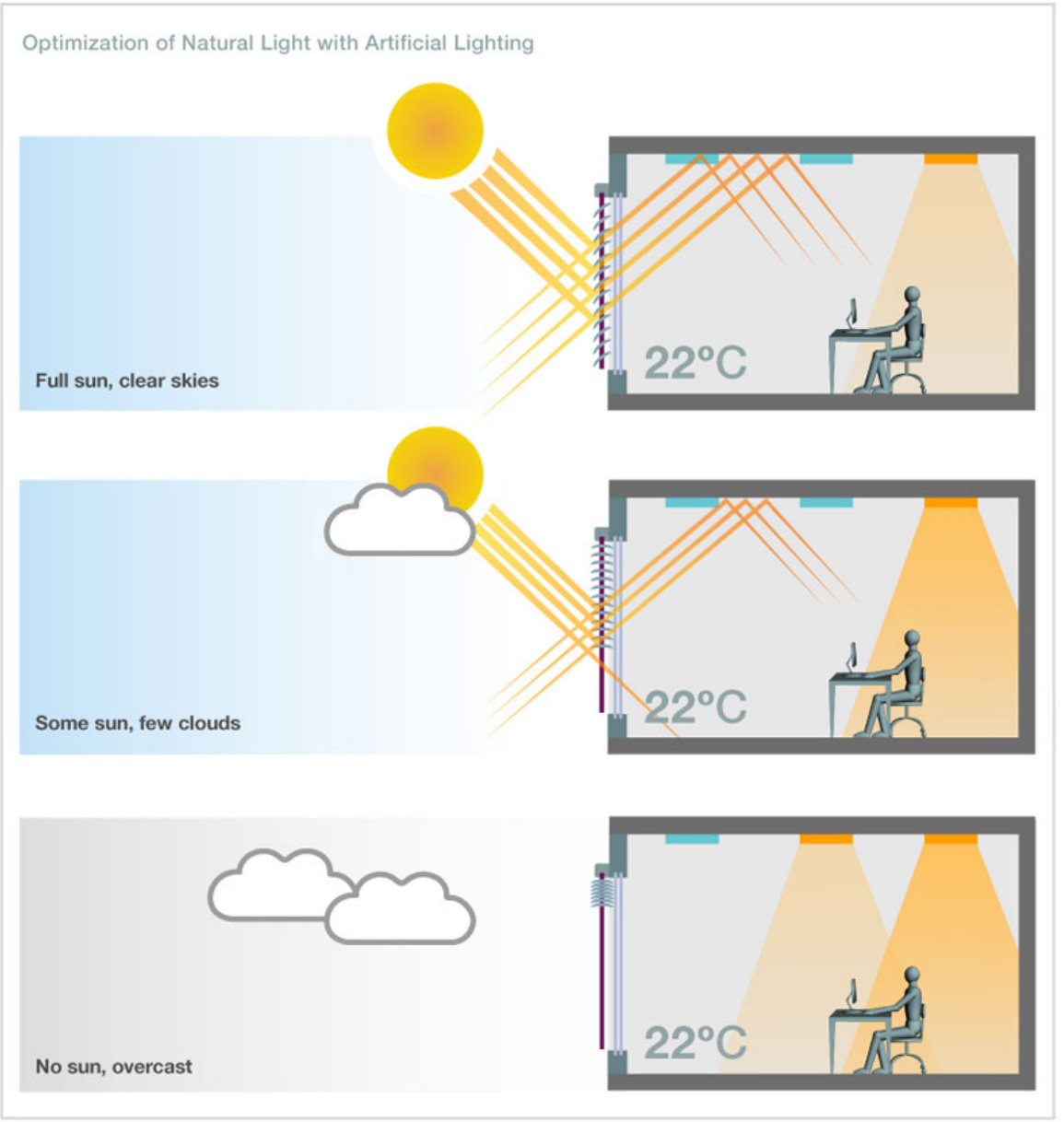
4.1.2.2 Lighting



Similar to thermal comfort, lighting is also important for the humans.

Lighting can be provided natural and artificial in the indoor environment.

There is need to optimize natural lighting with artificial lighting during the day time.

Source: http://www.sunproject.com/Images/sustainability/Combo-natural-artificial-light.jpg

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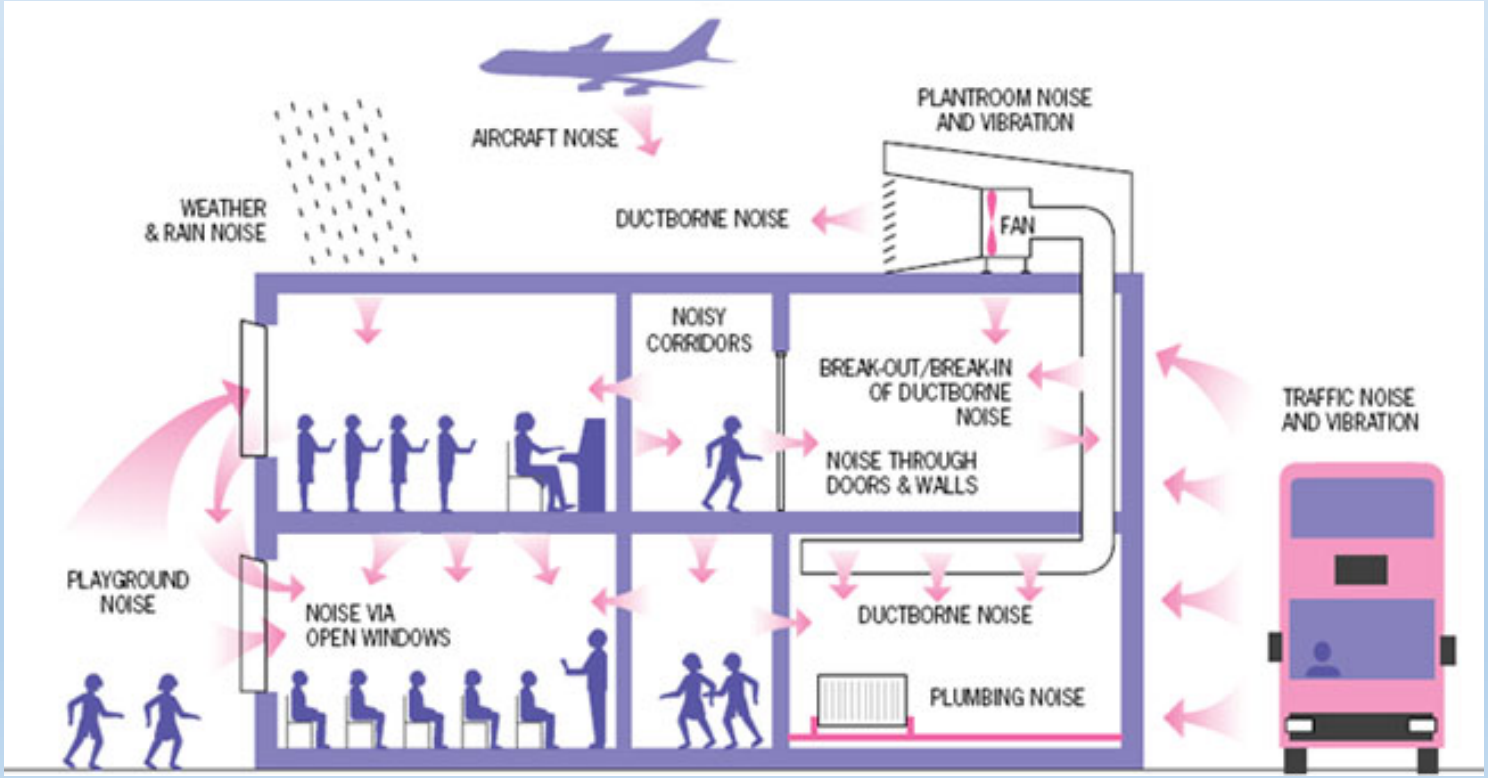
4.1.2.3 Sound Control

In modern living sound and noise is unavoidable.

Sound control (acoustics comfort) is very important for design since unwanted sounds disturb sleep and create anxiety.



Source: http://www.ursa.com/en-us/building-insulation/PublishingImages/acoustic-insulation.jpg

There are many sources of noise in daily life: Aircrafts, automobiles, trains, machines, generators, house hold appliances and entertainment.

For acoustic comfort there is need for a barrier between the source and receiver.

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4.2 Ergonomics

Ergonomics focuses more specifically on **people** and **machines**.

Similarly, this term is also originated from Greek:

ergon	+	nomos
“work”		**“natural laws"**

Ergonomics is a **science**, which is concerned with the **physical** and **psychological relationship** between **machines** and the **people** who use them.

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4.2 Ergonomics

Main **objective** of ergonomic studies is **adapting design objects** for the **human use**.

While designing objects, **people's capabilities** and **limitations** are taken into account.

This helps to ensure that the product is fit for use by the target users.

Reference: http://www.designingforhumans.com

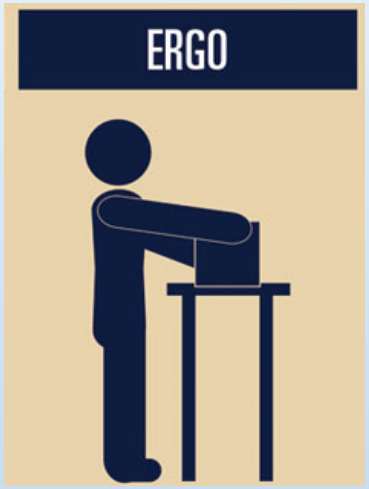
4.2 Ergonomics

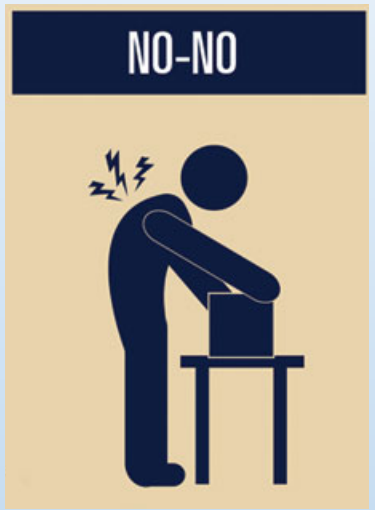
Ergonomic studies also searched to find ways to **keep people safe**, **comfortable**, and **productive** while they **perform tasks** at **work** and **home**.

Therefore, the **goa**l of ergonomics is to **design equipment, tools, job tasks,** and **the environment** to **maximize productivity ,efficiency, safety** and **comfort by reducing** worker **fatigue, stress, accident** and **discomfort**.

4.2 Ergonomics

The goal of ergonomic studies





- productivity
- efficiency
- comfort
- safety

MAXIMIZE

MINIMAZE

- fatigue
- stress
- discomfort
- accident

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4.2 Ergonomics

Ergonomics deals with different design scales varying from the design of **work areas** (including office furniture, automobile interiors, and aircraft cockpits etc.), to the disposition of **switches** and **gauges on the control panels of machinery** to determining the size, shape, and layout of **keys on computer terminals** and character height, color, and clarity on **video displays**.

That's why the field of ergonomics is also sometimes called **human** or **human-factors engineering**, **engineering psychology** and **biotechnology**.

References: B. M. Pulat, Fundamentals of Industrial Ergonomics (1992)

4.2.1 History of Ergonomics

The foundations of the **science of ergonomics** appear to have been laid within the context of the culture of **Ancient Greece and Egypt**.

A good deal of evidence indicates that Greek civilization in the 5th century BC used **ergonomic principles in the design of their tools, jobs, and workplaces**.

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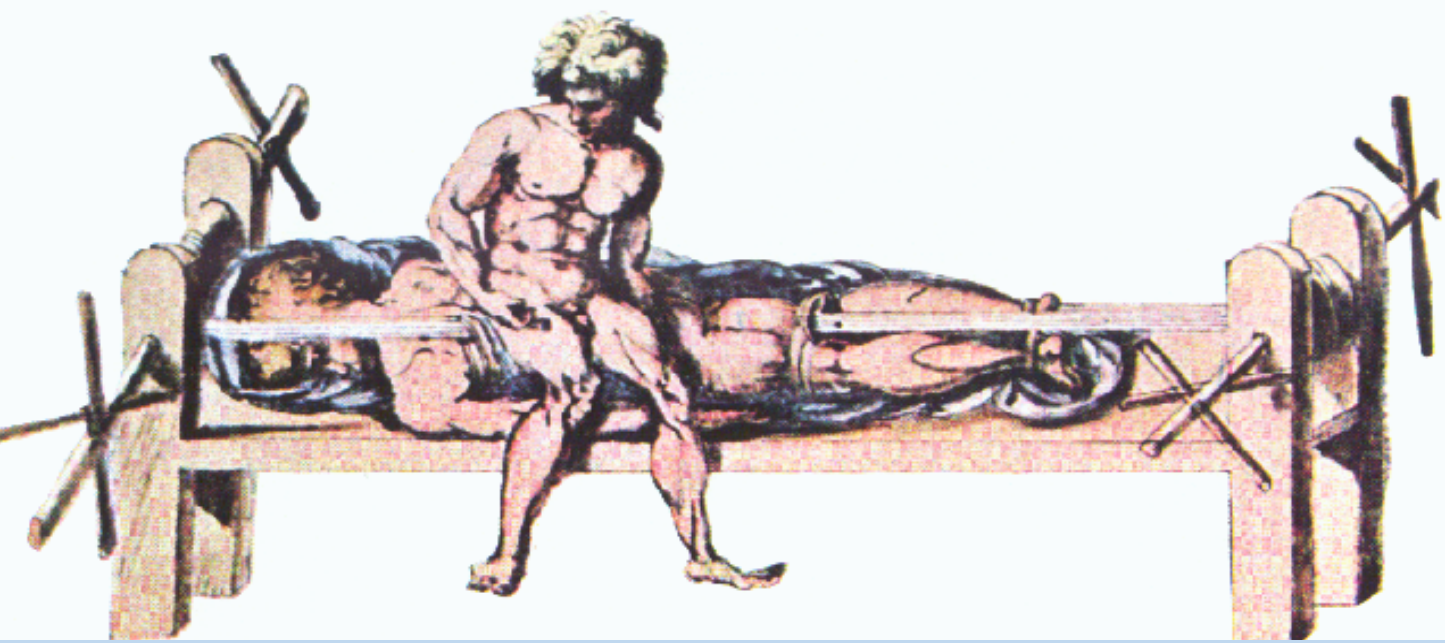
4.2.1 History of Ergonomics



Source: Wikipedia

One outstanding example of ergonomic studies in Ancient Greece can be found in the description Hippocrates gave of how a surgeon's workplace should be designed and how the tools he uses should be arranged.

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4.2.1 History of Ergonomics

Source: http://www.touregypt.net/images/touregypt/furniture2.jpg

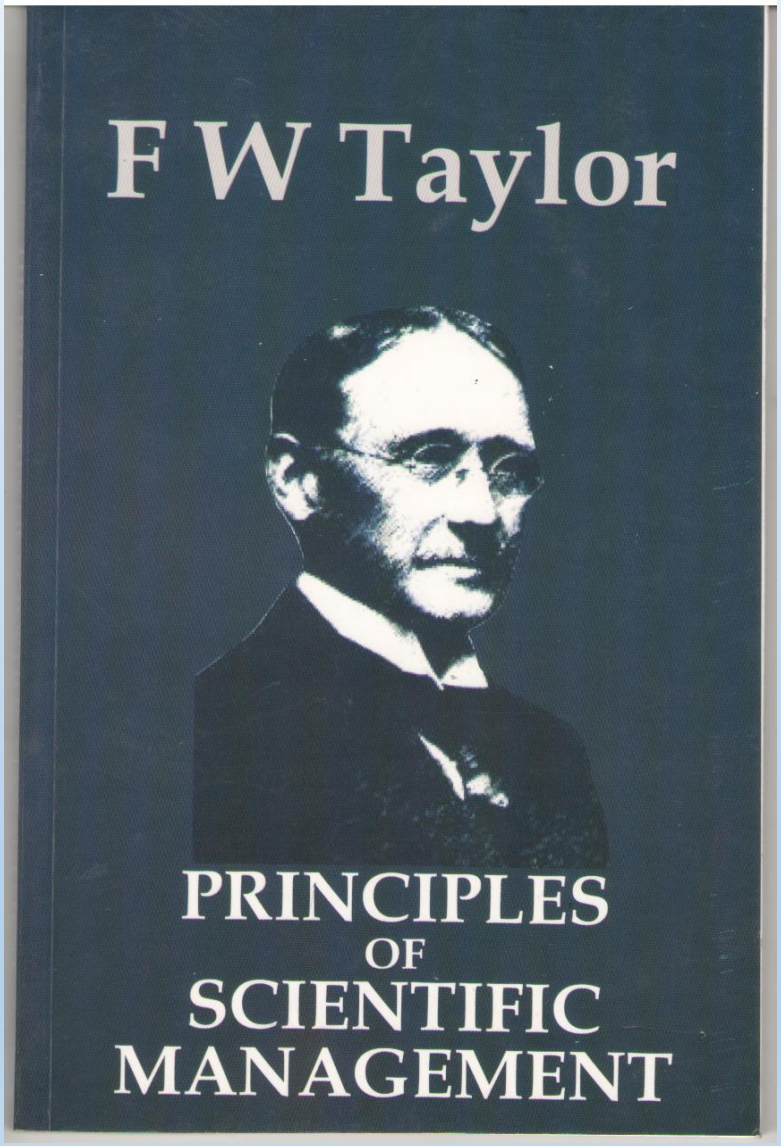
The archaeological record also shows that the early Egyptian dynasties made tools and household equipment that illustrated ergonomic principles.

4.2.1 History of Ergonomics

In 19th century, American mechanical engineer **Fredrik Winslow Taylor,** pioneered the scientific **management method**, which proposed a way to find **the optimum method for carrying out a given task.**

His efforts to improve industrial efficiency called as Taylor's Principles or **Taylorism**

4.2.1 History of Ergonomics

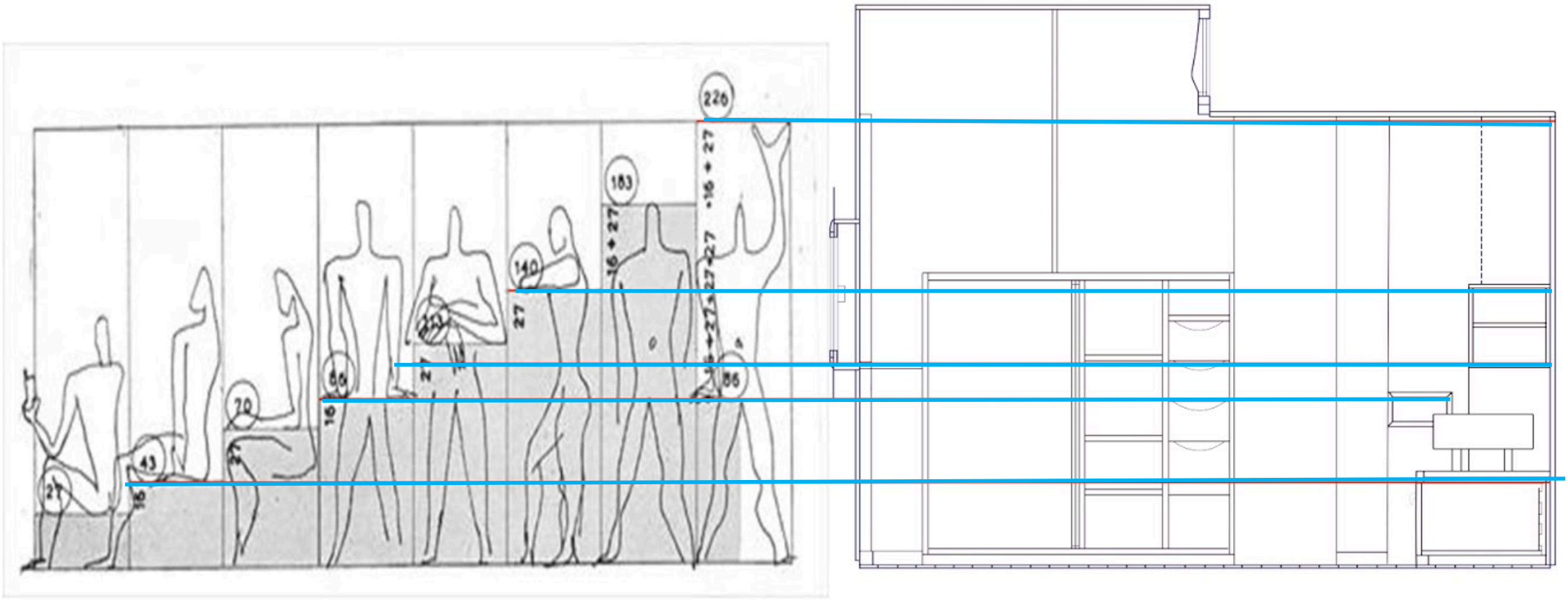


Taylorism became a theory of management that **analyzes** and **synthesizes workflows**.

Its main objective was **improving economic efficiency**, especially **labor productivity**.

Source: https://www.kullabs.com/uploads/fw.jpg

4.2.1 History of Ergonomics

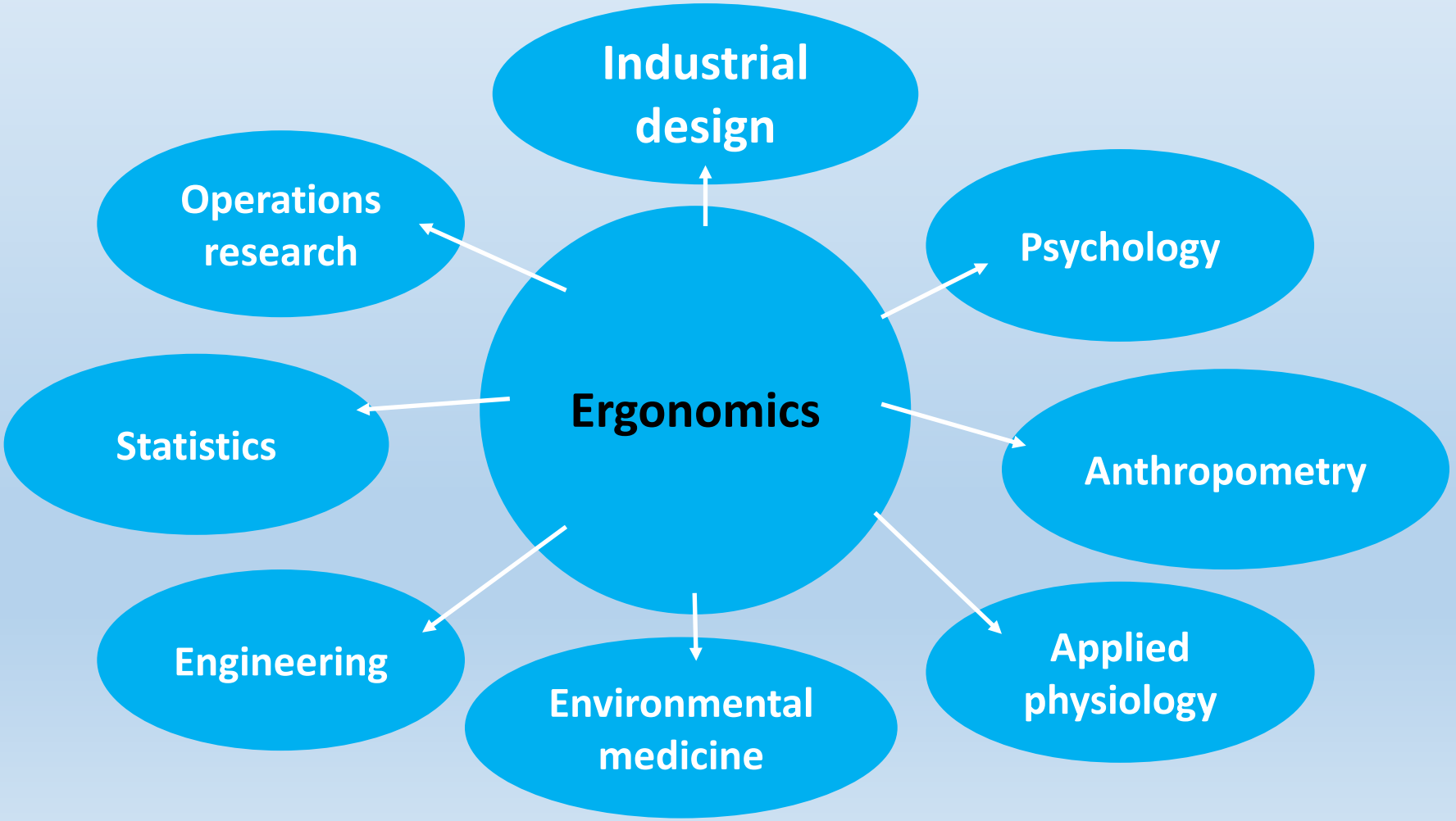


Source: http://2.bp.blogspot.com/-iPwtaPV1VAA/UMUH_7jT3pI/AAAAAAAAAQw/hhCOoKlqit8/s1600/Section+A+Modulor.jpg

Le Corbusier's studies in the 20th century also contributed to the ergonomics, especially in the residential environment.

4.2.1 History of Ergonomics

Today, ergonomics have became a multidisciplinary science



4.2.2 Ergonomics at Work environment

Over the 20 years **ergonomic injuries have gained recognition** as a major in work place health.

Ergonomics is **matching the job to the worker** and **product to the user**.

Ergonomics and human factors are often used interchangeably in workplaces. Both describe the **interaction between the worker and the job demand.**

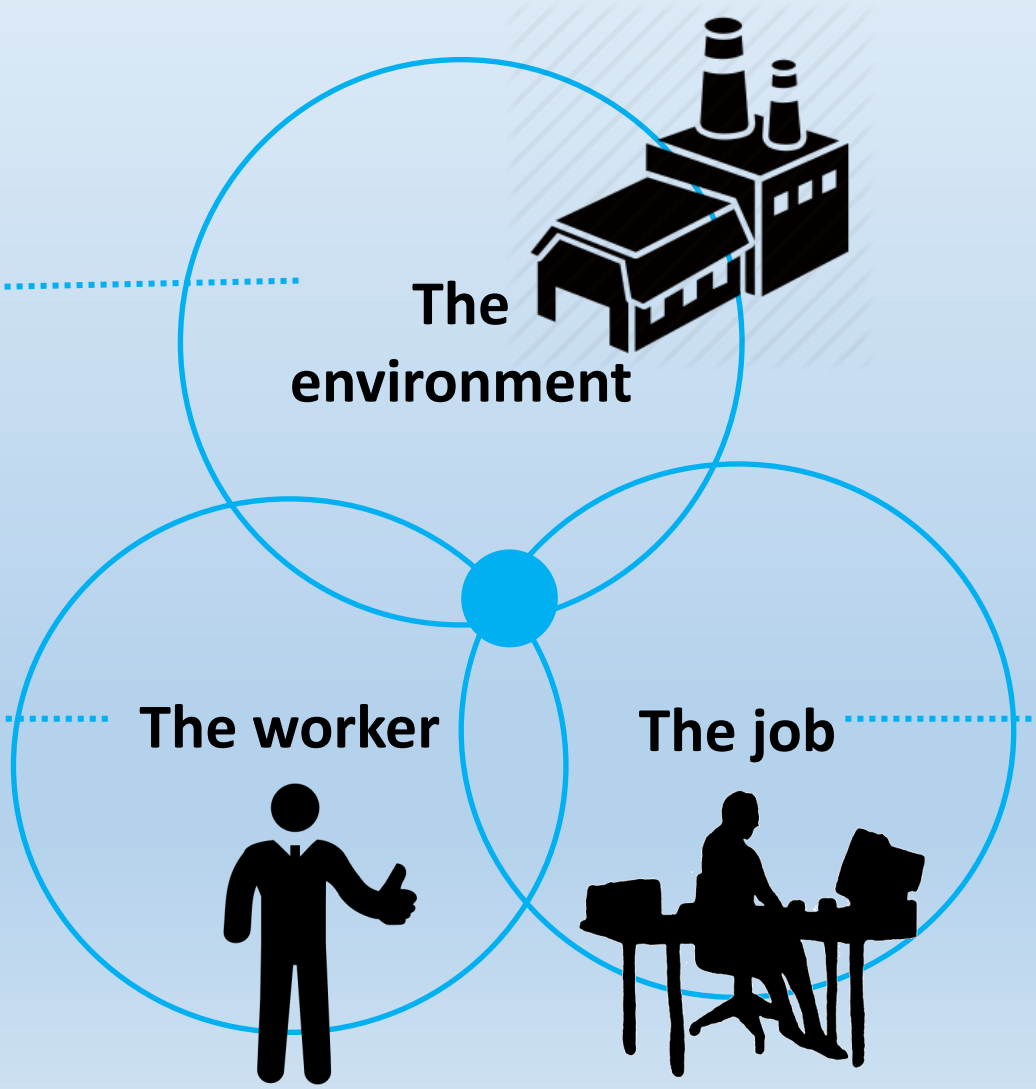
The differences between them is ergonomics focuses on how work affects workers and human factors emphasizes designs that **reduce the potential for human error**.

4.2.2 Ergonomics at Work Environment

How to provide good ergonomic in work places?

Noise, temperature, humidity etc.

Physical/mental capability, preexisting conditions, etc.



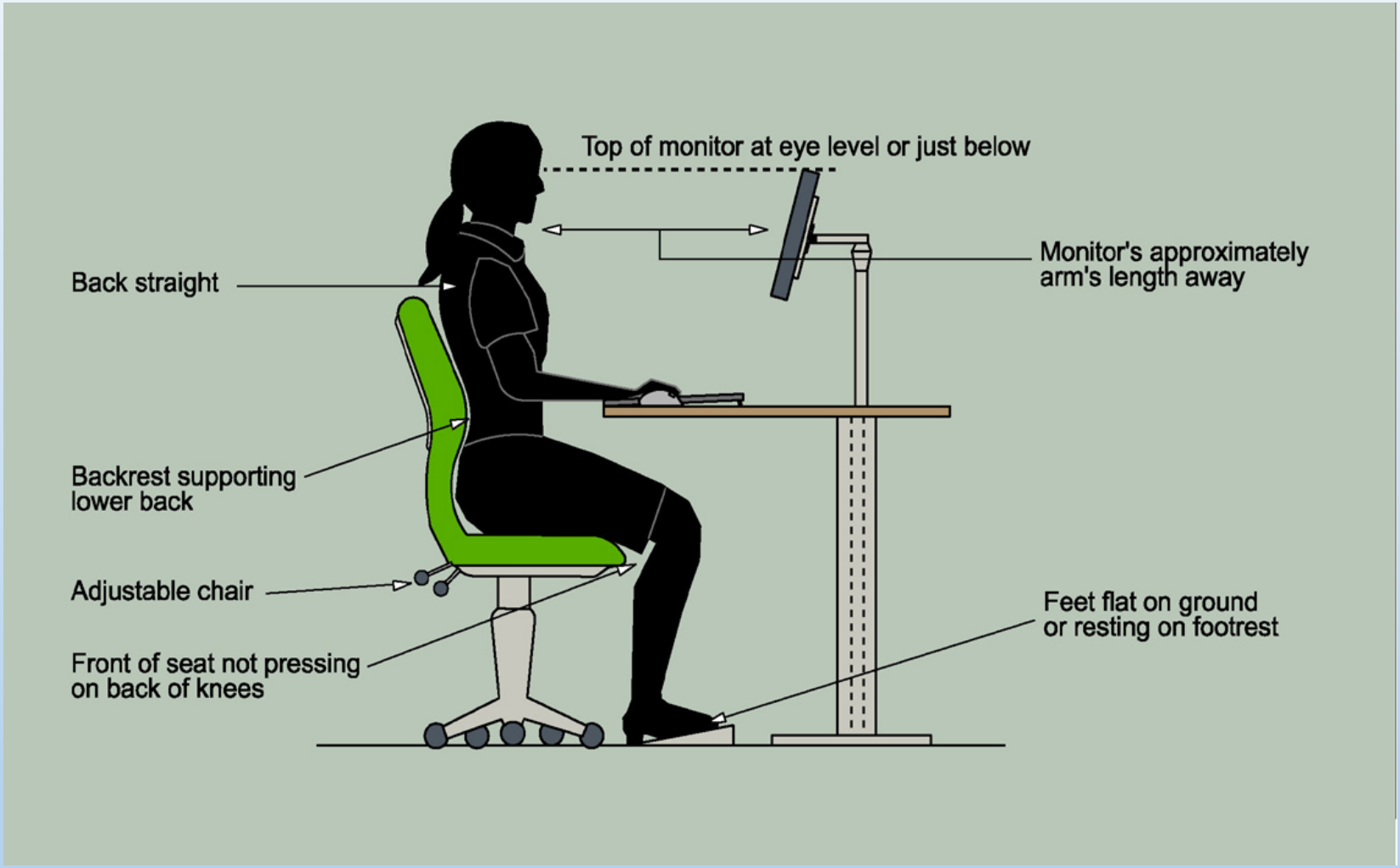
Heavy, Frequent, or Awkward Lifting
Pushing, Pulling or Carrying Loads
Working in Awkward Postures
Hand Intensive Work
Repetitive motions
Forceful exertions
Vibration

4.2.2.1 The Worker at Work Environment

No matter what the job is, the worker's **body is not compromised** at all in work place.

Ensure the **body position** and **posture** in conductive to **comfort** and have minimal distraction from physical discomfort.

4.2.2.1 The Worker at Work Environment



Source: http://www.ibsproduces.com/wp-content/uploads/2013/11/workspace-set-up.jpeg

The design of workstations should be based upon anthropometric data, behavioral patterns of employees and specific requirements of the work being done.

4.2.2.2 The Environment at Work Place

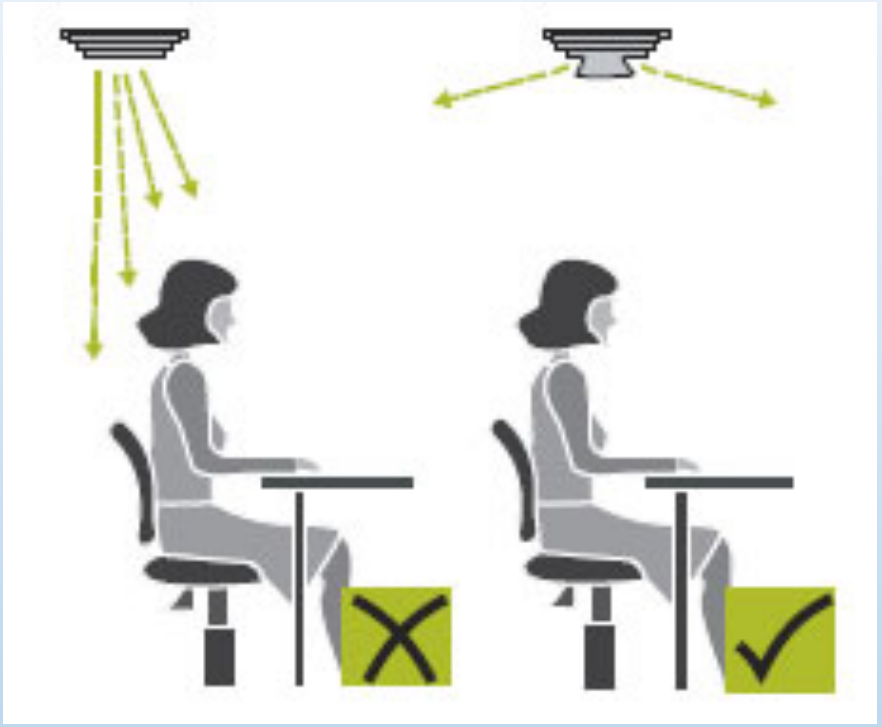
Control of the **noise**, **temperature**, **humidity**, etc. are important at the work environment.

Elevated temperatures and humidity can be harmful.
Low temperatures can reduce finger flexibility and accuracy

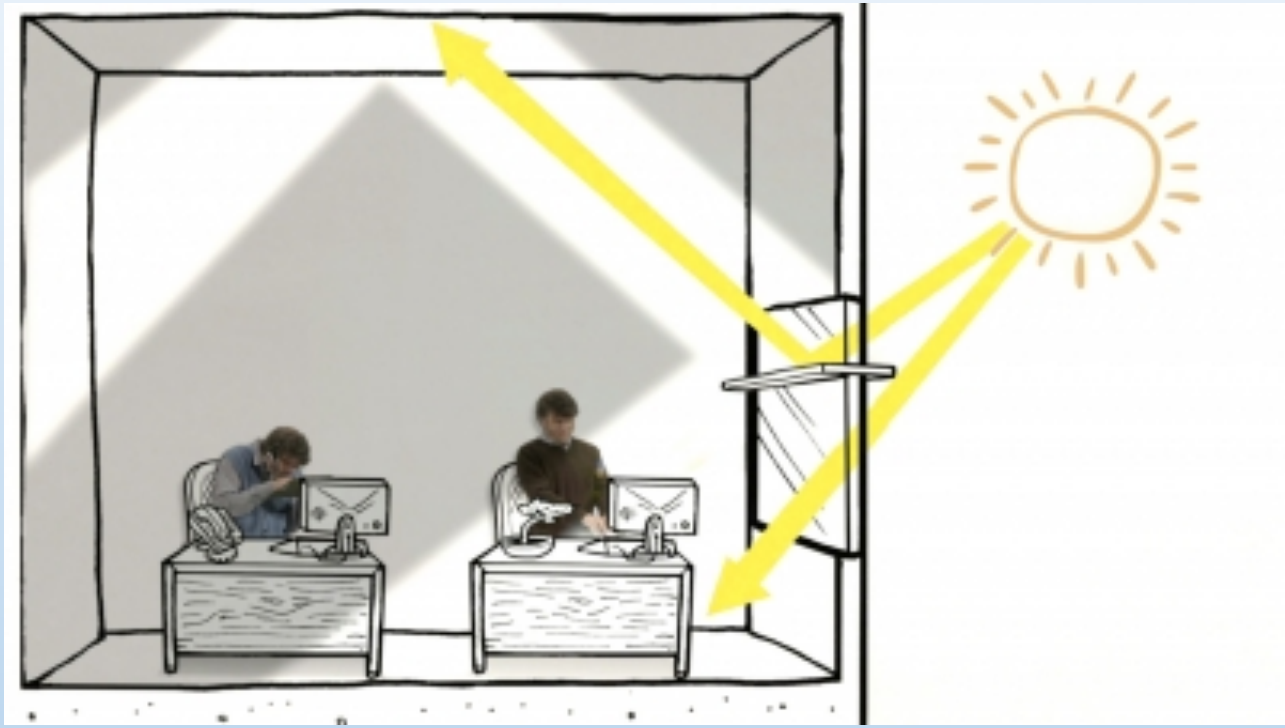
Lighting is another important aspect. Computer screens /other workstations may need to be repositioned to eliminate glare. Monitor's brightness also should match the room.

High exposure to loud noise over a long period of time causes deafness and other audiological disorders.

4.2.2.2 The Environment at Work Place



Source: http://www.corporateseating.com.au/wp-content/uploads/4.7.jpg



Source: http://auworkshop.autodesk.com/sites/default/files/styles/ucp_400x225/public/core-page-images/lightshelf.jpg?itok=H7VQOjKN

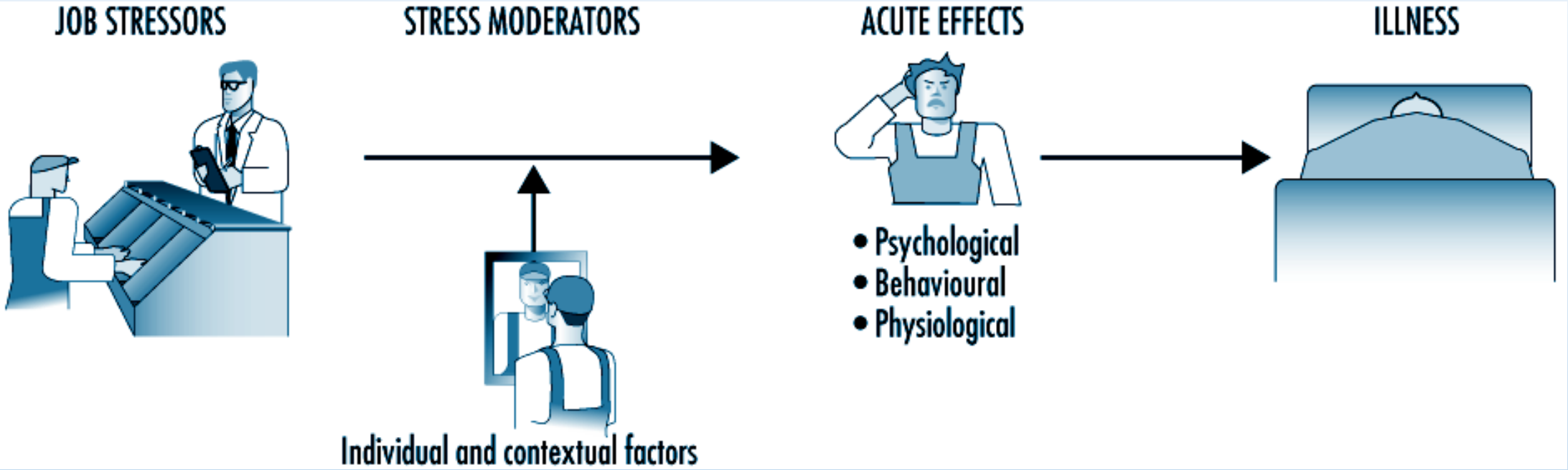
Control of the noise, temperature, humidity, lighting etc. are important at the work environment.

4.2.2.3 The Job at Work Environment

All occupational activities involve varying degrees of muscular work and sets of posture and movements. Therefore it is important to provide **adequate job to the limits of the body**.

Moreover, correct arrangement of hours of work, break times, adequate paid holidays, correctly organized work flows are extremely important.

4.2.2.3 The Job at Work Environment

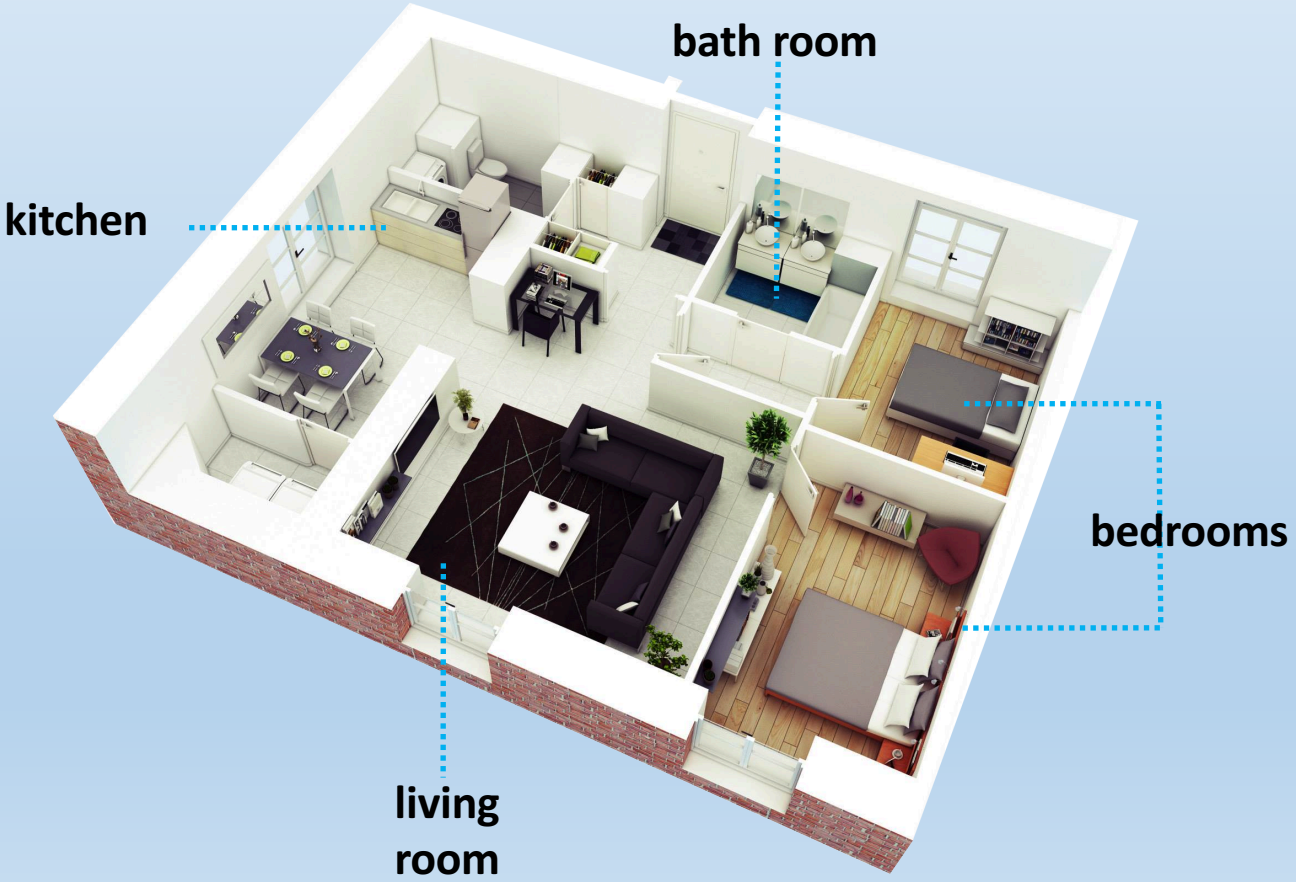


Source: http://www.ilocis.org/documents/images/psy01fe.gif

Time pressure, heavy work hours, spending too much of body power, inadequate rest may cause stress and illness at the work place.

4.2.2 Ergonomics at Home Environment

Similar to workplace ergonomics, **home ergonomics** is the science and study of **fitting the home to the resident**.



Home ergonomics is the idea of having **components of a home** that have been **designed with the body's comfort** in mind and **prevent injuries.**

4.2.3.1 Kitchen

Kitchen is the **heart of the home**.

Two things are important at ergonomic kitchen design '**kitchen work triangle**' and ergonomics of good **lighting**.

The key ingredients of an accessible kitchen also include:

1. Adequate space for moving around in work surfaces located at an appropriate height
2. Access to the car and the waste disposal area to enable easy transport of groceries and rubbish
3. Access to the meals or dining area where food will be consumed
4. Adequate and appropriate storage suitable cooking devices
5. Suitable lighting ,convenient fittings, handles and control

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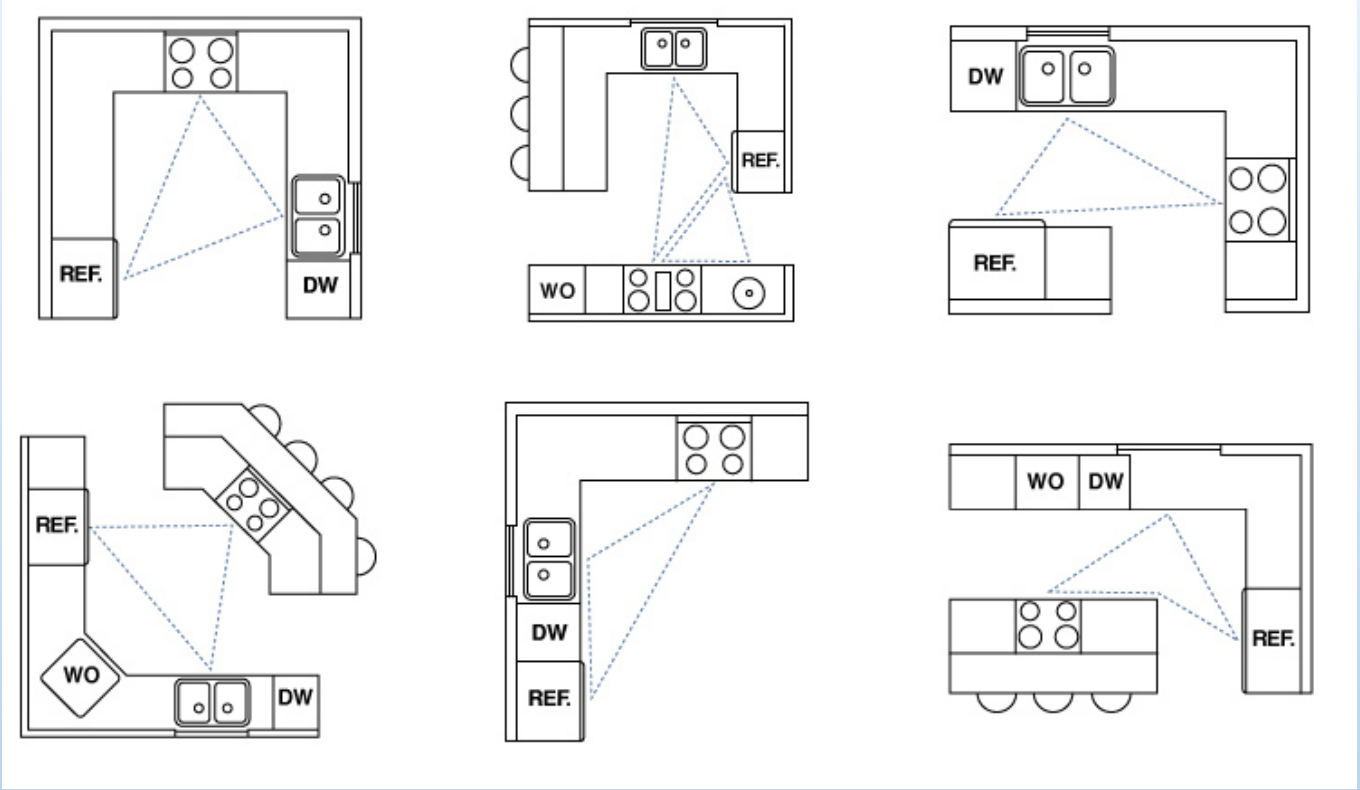
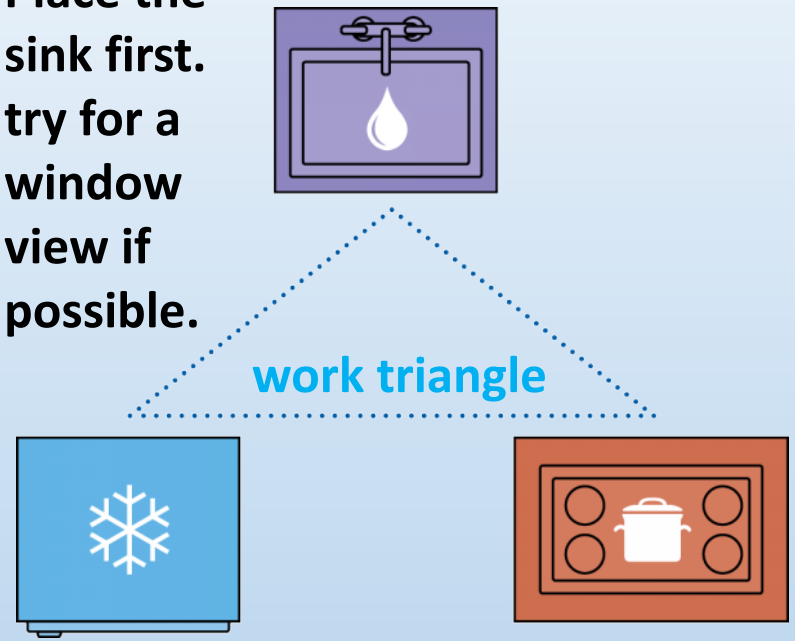
4.2.3.1 Kitchen



Source: http://5litn2sb3a6yphwy4due7pibj.wpengine.netdna-cdn.com/wp-content/uploads/2014/05/kitchen-work-triangle-kohler.png

Various type of kitchen plan is possible based on the "work triangle" principle

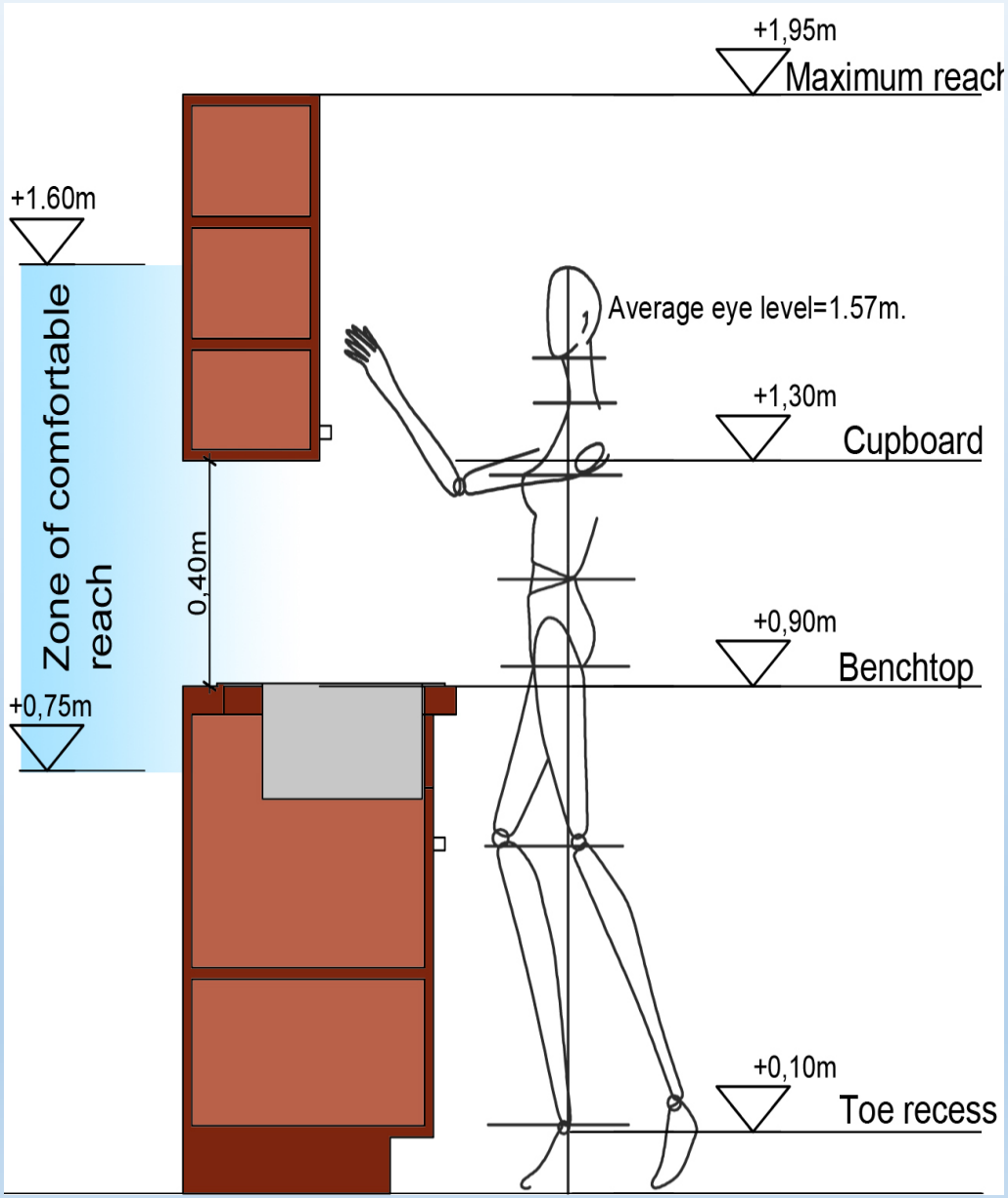
Place the sink first. try for a window view if possible.



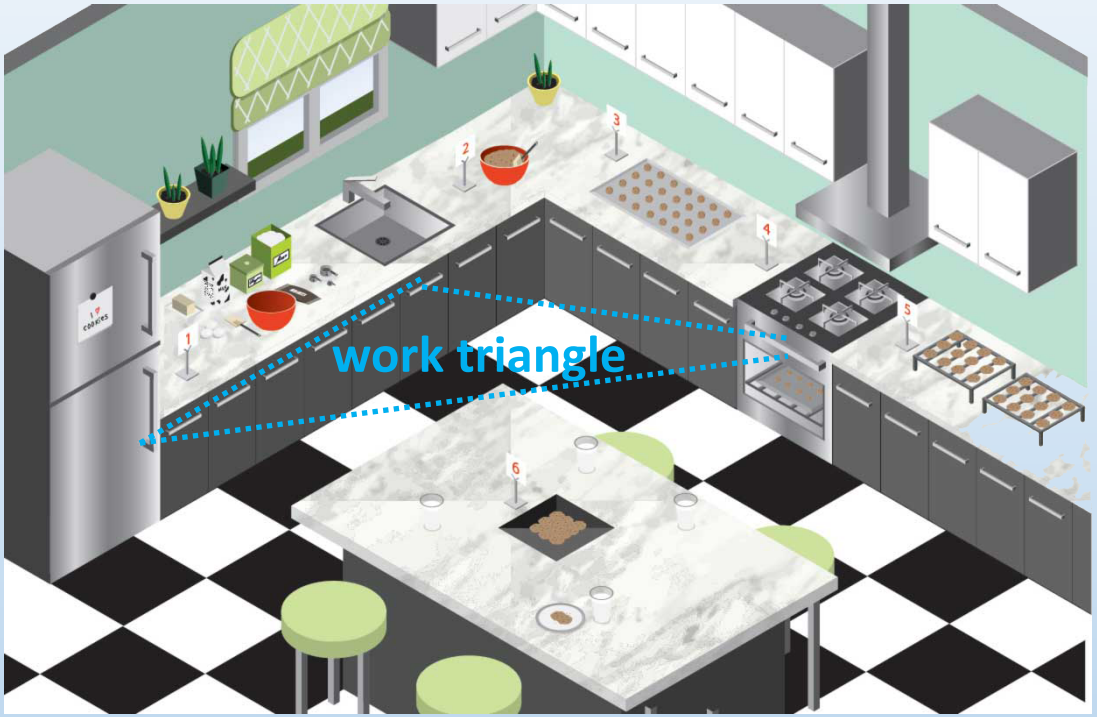
It is helpful to have countertop space next to the fridge, for when you take food out.

Keep the distance short between stovetop and sink since heavy pot or hot water will be carried.

4.2.3.1 Kitchen



Source: http://cedarruntownhomes.com/standard-countertop-height-kitchen/standard-countertop-height/



Source: http://erin-graham.ca/images/design/drawing/isometric.jpg

All the furniture, kitchen cabinets, sink must have appropriate size for the user.

Lighting is very important in the kitchen.

4.2.3.2 Living Room

The **living room** is usually the **largest room in the house**.

If the kitchen is the heart of the home, the living room is its **center** and it is used by every member of the house.

- The selected furniture should meet with all of the user's body comfort **(For example on coach or armchair your feet should touch the floor when sitting in your typical position).**
- The proper lighting, cooling and heating should be provided.
- The noise control should also be considered.
- When positioning TV/PC screens ensure they are at the right height for eye focus so there is no strain. **TV's should be wall mounted or standing in a position that is comfortable for all people to watch so you head and neck do not feel strain.**

4.2.3.2 Living Room

Source: http://www.interiordesigninspiration.net/wp-content/uploads/2014/01/Small-Living-Room-Designs-001.jpg

Natural and artificial heating and cooling should also be considered

Control of noise (doors, walls, windows)

4.2.3.3 Bathroom

Bathroom is an environment to **relax.** **However it** also contains workstations for the practical activity of washing.

Bathroom design must be "**user specific**".

- Since user (such as children, wheelchair person or others) needs varies in the bathroom, it is important to about the user's **physical form dimensions**.
- Second it is important to identify if user wants bathroom open to the bedroom or set apart and private.

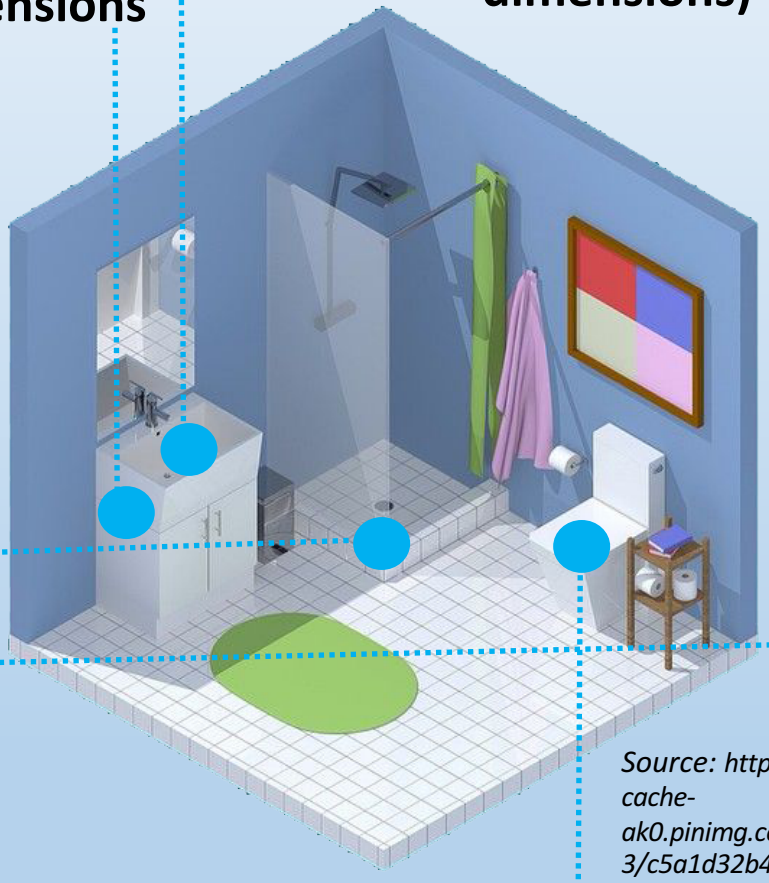
4.2.3.3 Bathroom

Cabinet based on user dimensions

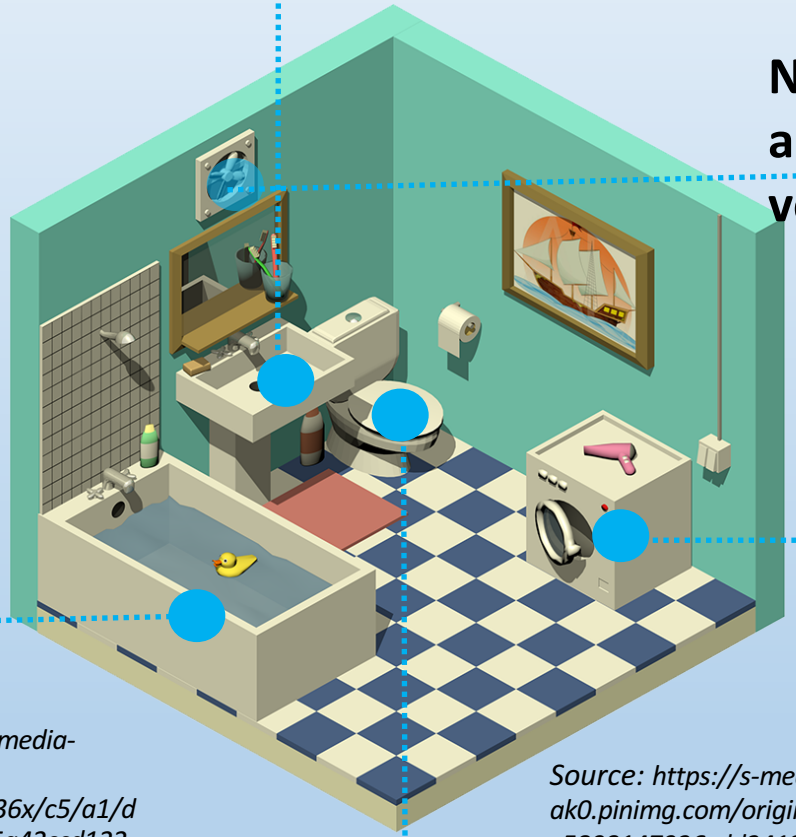
Sink (based on human dimensions)

Natural or artificial ventilation

Based on the user preference and dimensions bath or shower



Source: https://s-media-cache-ak0.pinimg.com/736x/c5/a1/d3/c5a1d32b4e7f65a42ccd1223bf01e30e--low-poly-motion-design.jpg



Source: https://s-media-cache-ak0.pinimg.com/originals/ba/c5/80/bac5808147926cdd341307c937f052fe.png

Optional washing machine

Water closet (with accessories for the users with special needs)

Lighting, humidity and sound control as well as floor material is also important in bathroom

4.2.3.4 Bedroom

Most amount of time in bedroom take place in the bed while sleeping. Therefore the **noise control** and **comfortable bed** are very important for human well-being in bedroom.

- The bedroom should be located near to a bathroom.
- Small child's bedroom should be near parents' bedroom
- There should not be bathroom or shower at children's bedrooms due to safety reasons.
- Wardrobes should be located by considering to leave enough space for circulation after opening them.
- If there is a double bed in the room, from both sides there should be enough space for two people to get in and out separately.

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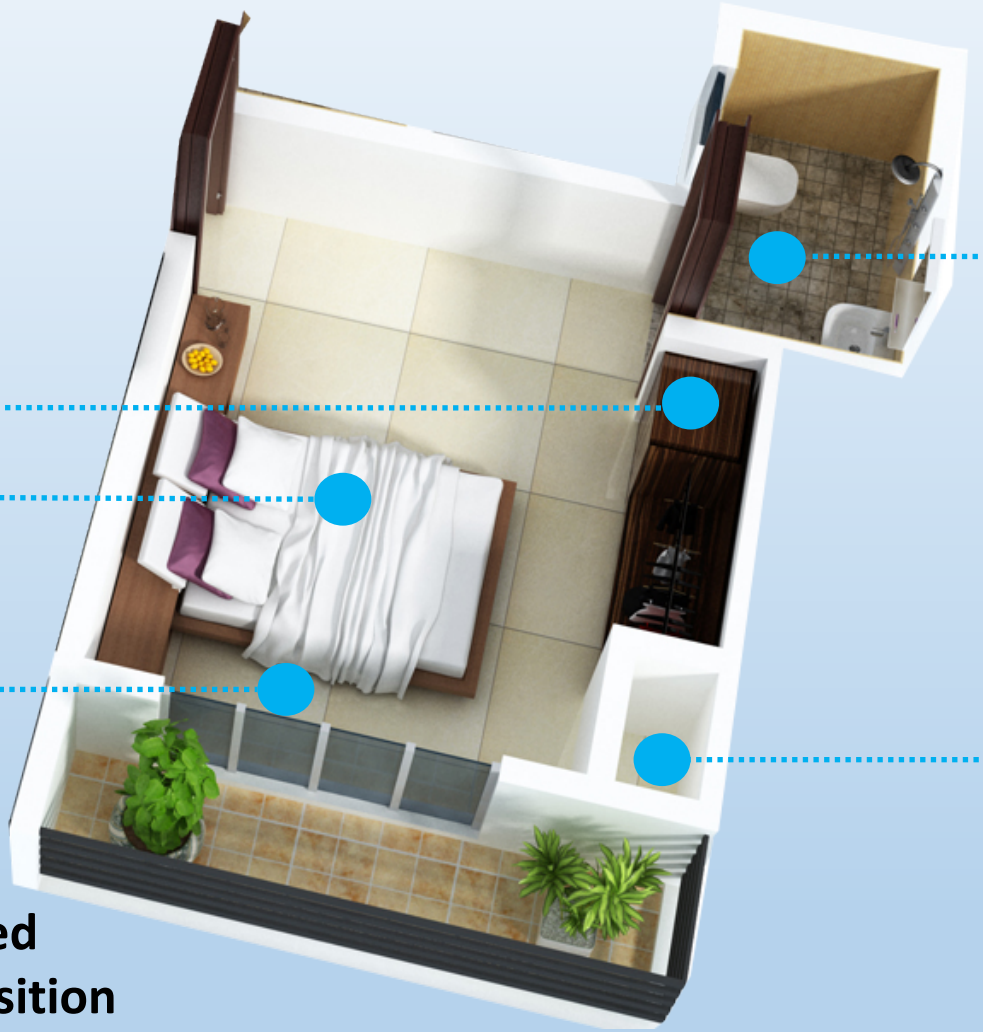
4.2.3.4 Bedroom

Dressing table with the mirror (user dimensions must be considered)

Comfortable bed

Enough space at the both sides of the bed for circulation



Separate bathroom (optional) opening to the bedroom- only in adult's room

Wardrobe (may also be designed as a small dressing room)

If a TV unit is expected in the bed room, it should have correct position height and distance.

Source: http://3.bp.blogspot.com

Natural and artificial heating &cooling and lighting should also be considered