

**Building Biology & Ecology**  
*Healthy by Design – an introduction*

**David Gale** (ARB RIBA Dip Perm Des)  
Gale & Snowden Architects & Engineers



# An integrated approach



Low Energy Design



Permaculture Design



Passivhaus Certified



Healthy Buildings

Building Science - Physics and Biology

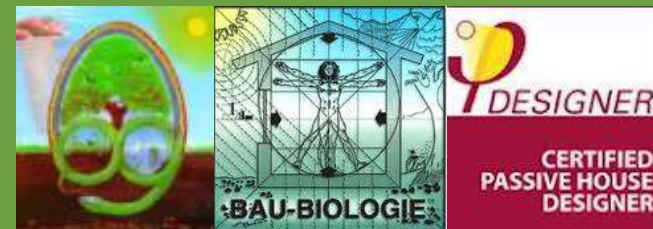
Architects

Mechanical and Engineers

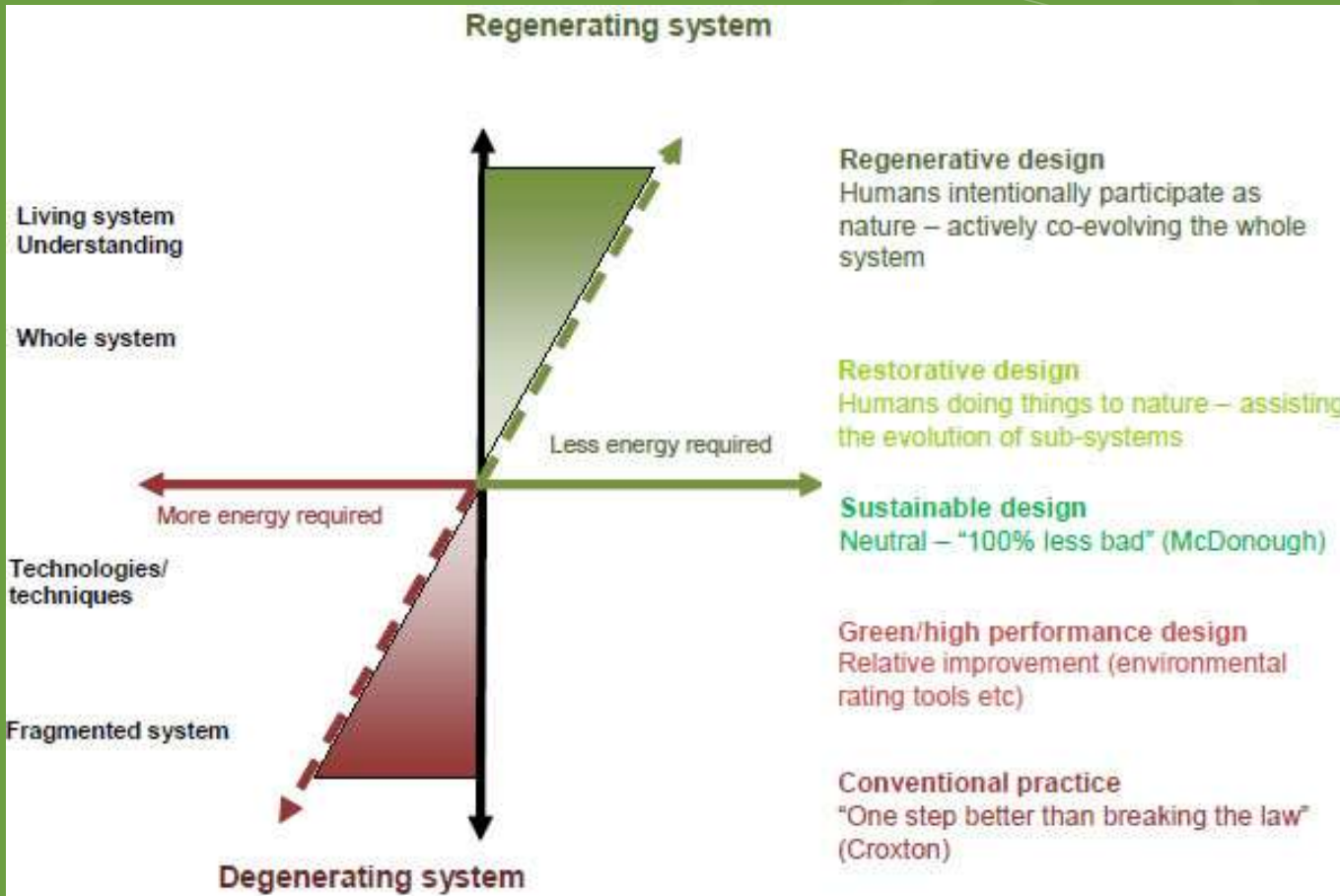
Permaculture designers

Passivhaus designers

- Climate Ready Design
- Building performance monitoring & evaluation
- Component and product design



# Trajectory of environmentally responsible design



Most systems we currently have in place are degenerating systems:

- unhealthy
- polluting
- depleting resources
- destructive
- working against nature

Regenerative systems:

- understand how nature functions
- use natural processes as design tools
- employ sound building physics and building biology
- generate more bio-activity than before
- Healthy by Design

Designing for people as part of ecosystem

Projects that improve their environment, are as impact-free as possible, anticipate future needs and are healthy

# Crippets – refurbishment and landscape, Devon



## Air quality / materials:

- natural & vapour permeable
- non toxic (lime wash, organic paints, stains, waxes)
- locally sourced using local craftsmen
- natural ventilation
- reduce dust mite habitat – clay tiles, slate, cork and solid floor boards

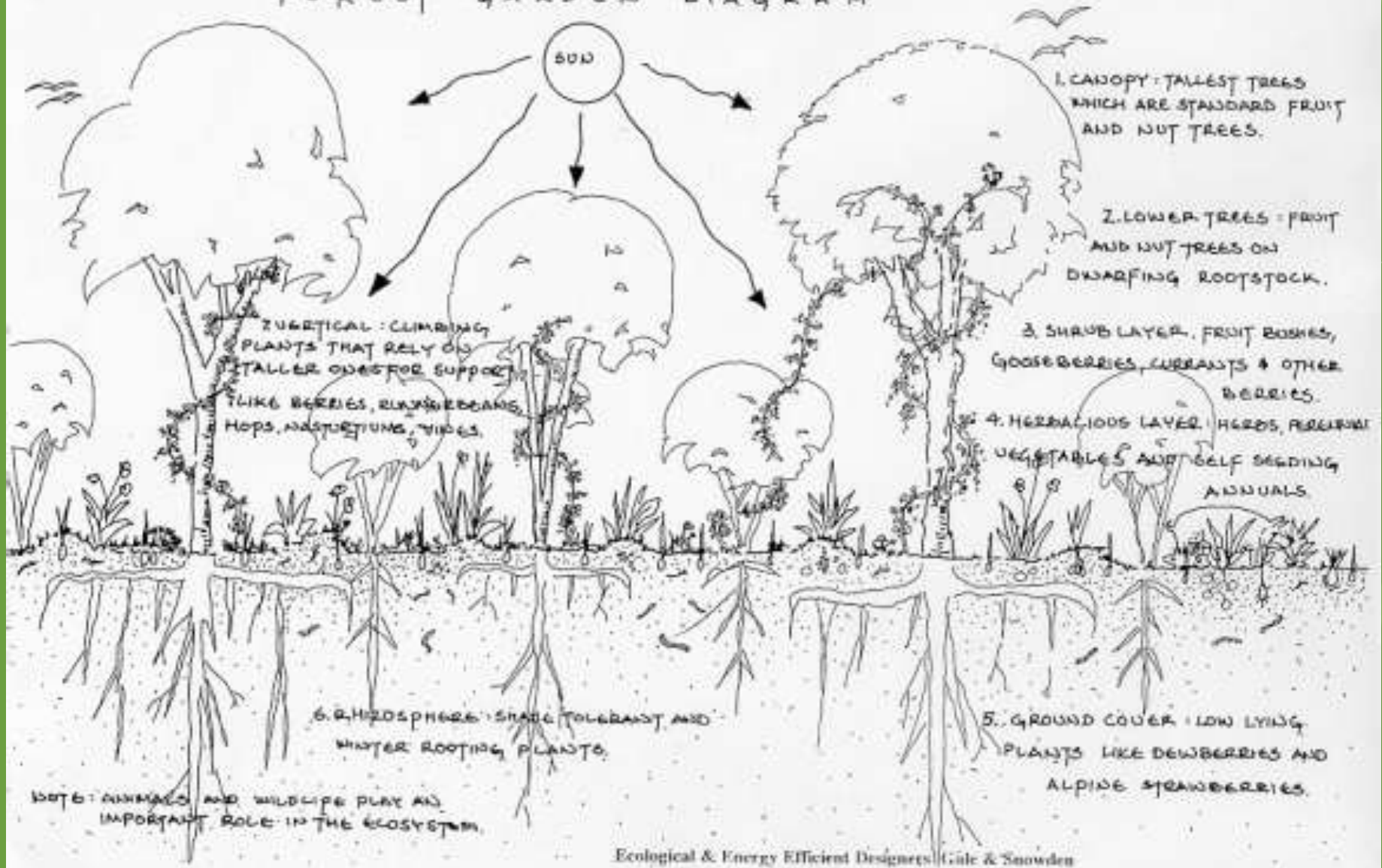
## Water quality

- well water
- whole house treatment via particle filtered and UV treatment

## Energy

- thermal comfort - insulation of building envelope, draft proofing, thermal blinds
- wood burning – cooking, heating and hot water
- EMR reduction by limited wiring and appliances, fuse board in lobby space

# FOREST GARDEN DIAGRAM



Seven layers of a Forest Garden – edible community of species designed to mimic a natural ecosystem



Crippets, forest garden - early days

Forest Garden  
maturing

edible  
Ecosystems

Nutrient wheel









Integration of people  
and productive  
ecologies

Aquaculture and  
aquatic systems

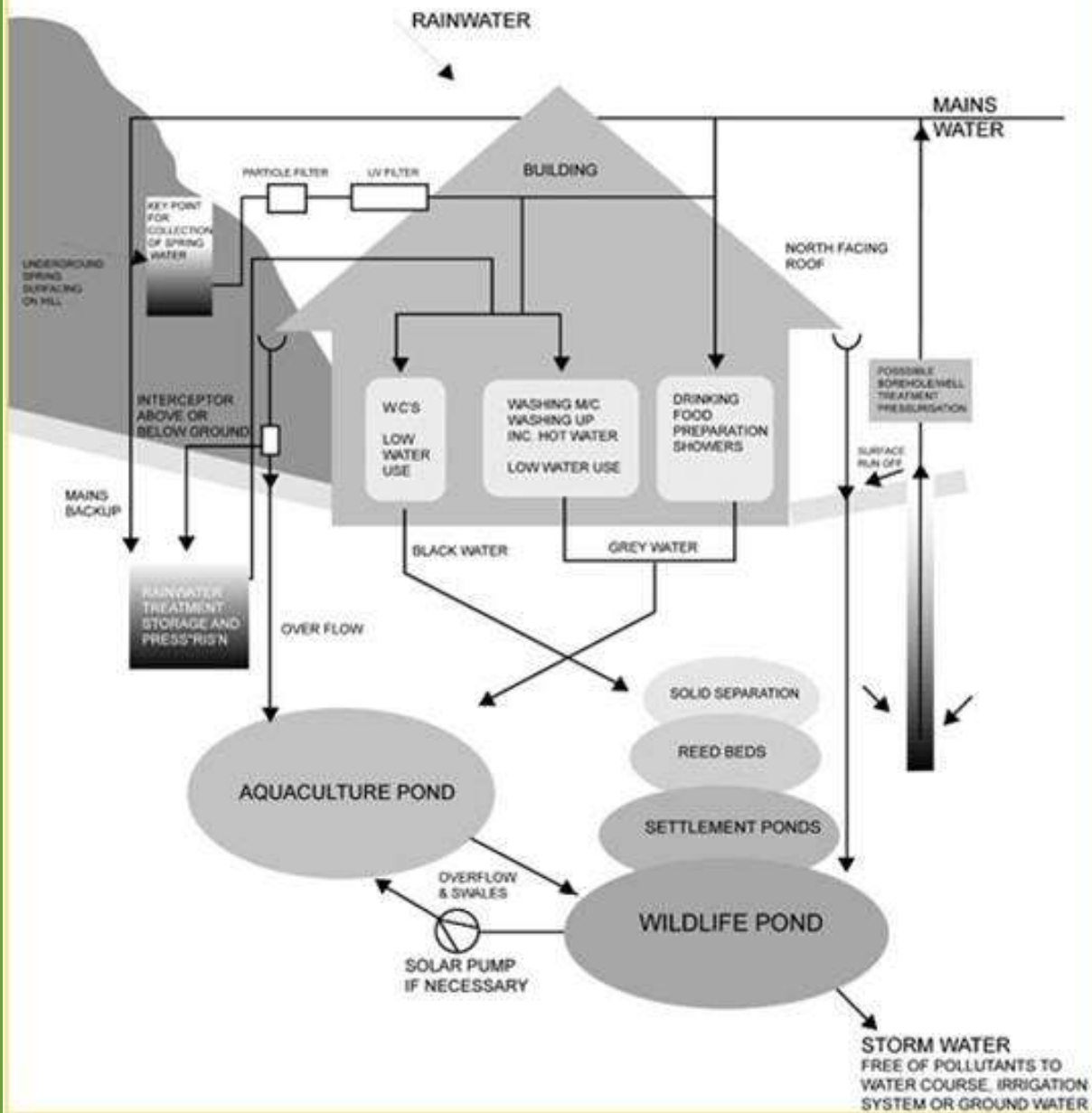
Reed bed system

Nutrient recycling

Forest garden



# ALTERNATIVE WATER STRATEGIES



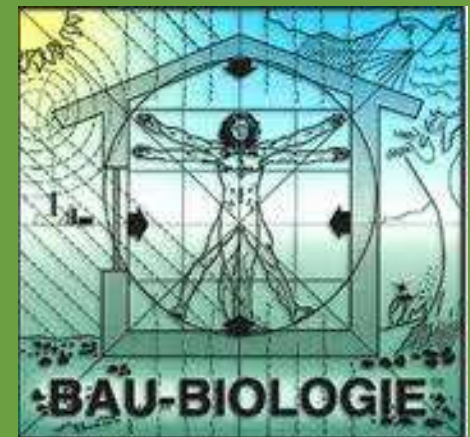
# What on earth is 'Building Biology'?

Building biology is defined as the study of the holistic interrelationships between humans and their living environment

- creating healthy buildings
- maintaining or restoring a healthy ecology

First founded in Germany by a group of professionals in the 1960s from a variety of disciplines concerned about the inability of post war housing to support health and ecology

The movement has grown to other countries and now is a recognised authority on healthy buildings



# What does 'Building Biology' involve?

At first glance a 'shopping list' of building technology eg:

- Non toxic building materials
- Healthy aspects of indoor air quality
- Ensuring high water quality
- Proper electrical wiring, etc

Whilst this is part of the picture, looked at holistically, Building Biology extends into many related fields which are otherwise taught in isolation:

- Ecology, biology, medicine, architecture, engineering, education, economics, energy conservation, etc

Building Biology is a living subject dealing with the interrelationship of disparate disciplines



Construction Resources, London

# What is a 'Healthy' building?

*'Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity'  
(World Health Organization)*

For good health we need:

- Healthy Diet
- Exercise
- Healthy environment

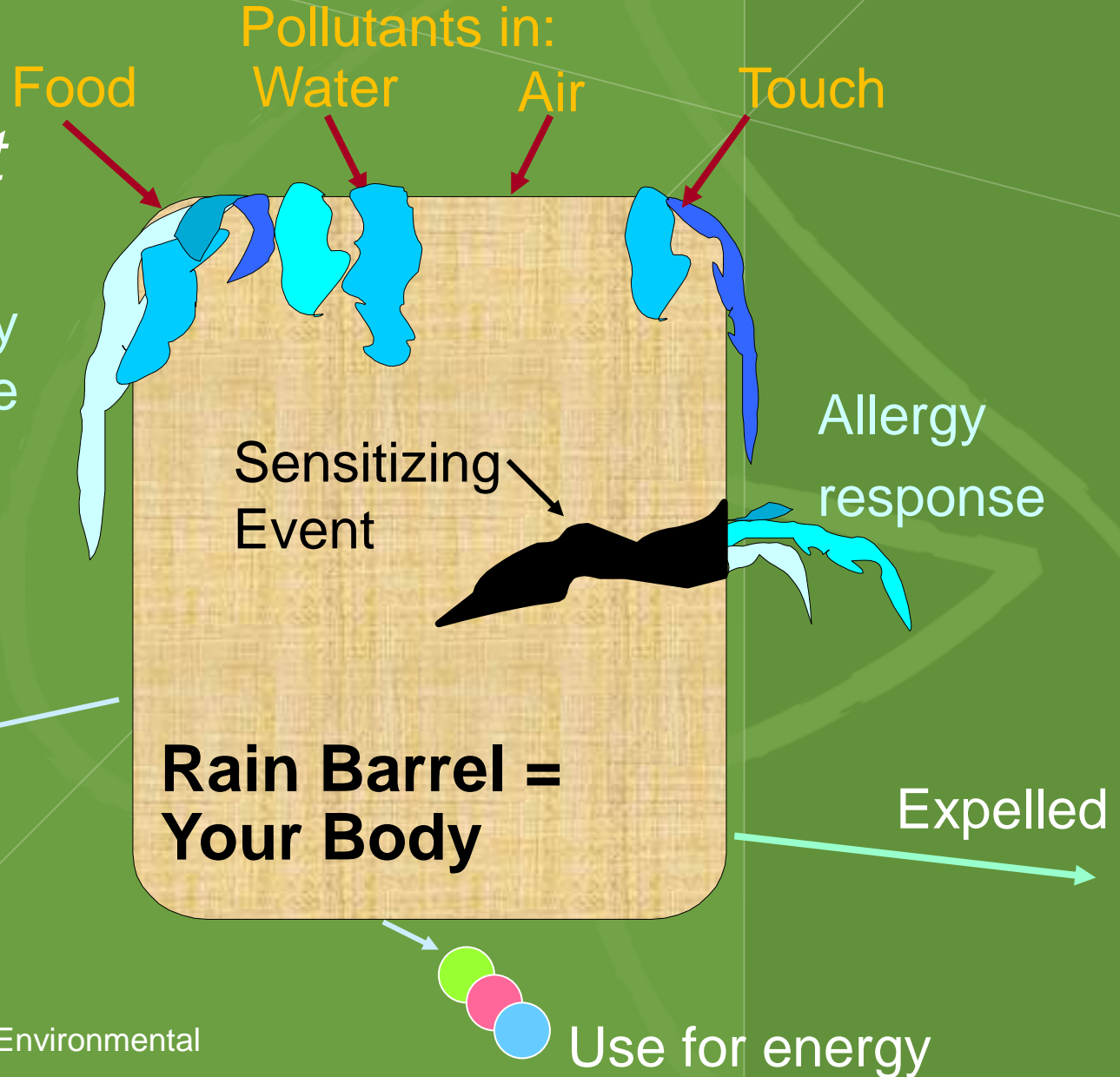
Often people are unaware that their built environment can be detrimental to their health

**Healthy Diet**  
+  
**Exercise**  
+  
**Healthy Environment**

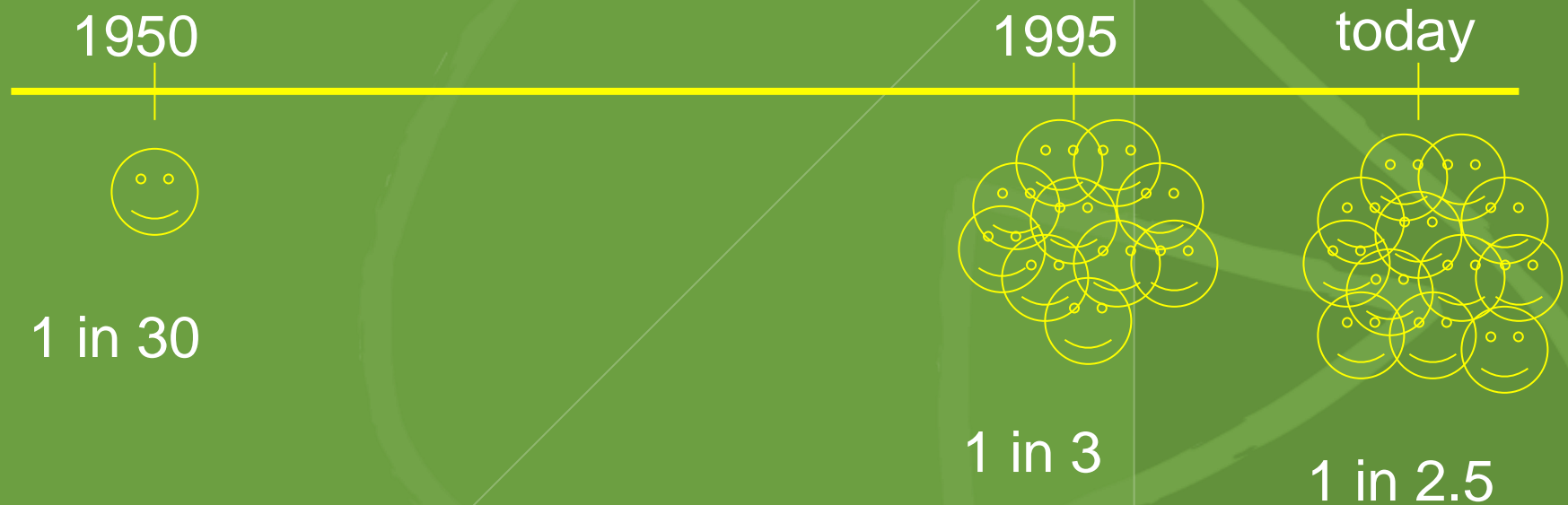


# What effect does our environment have on us?

## *The Rain Barrel Effect*



# Allergies and Asthma



Allergists claim 50% of illness caused or worsened by indoor pollution



# Key Building Biology Concepts

## The Golden Rule

- Nature is the measure to which our internal environment should operate

## The 3<sup>rd</sup> skin

- Buildings are our third skin

## Permeable buildings

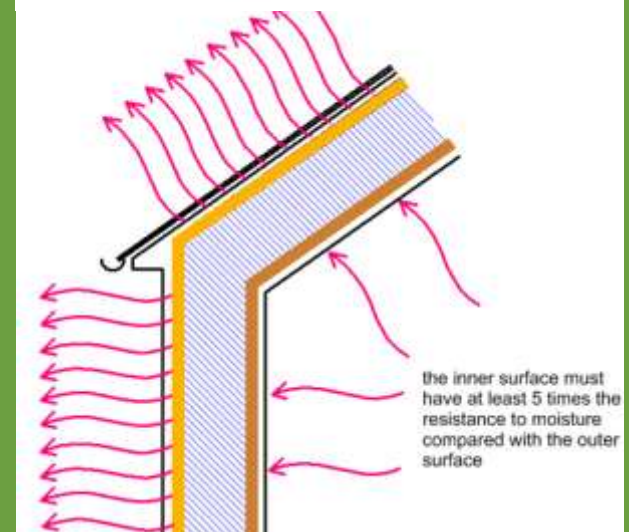
- Buildings should be moisture vapour permeable

## Life enhancing

- A healthy building is a building that uplifts and nurtures us

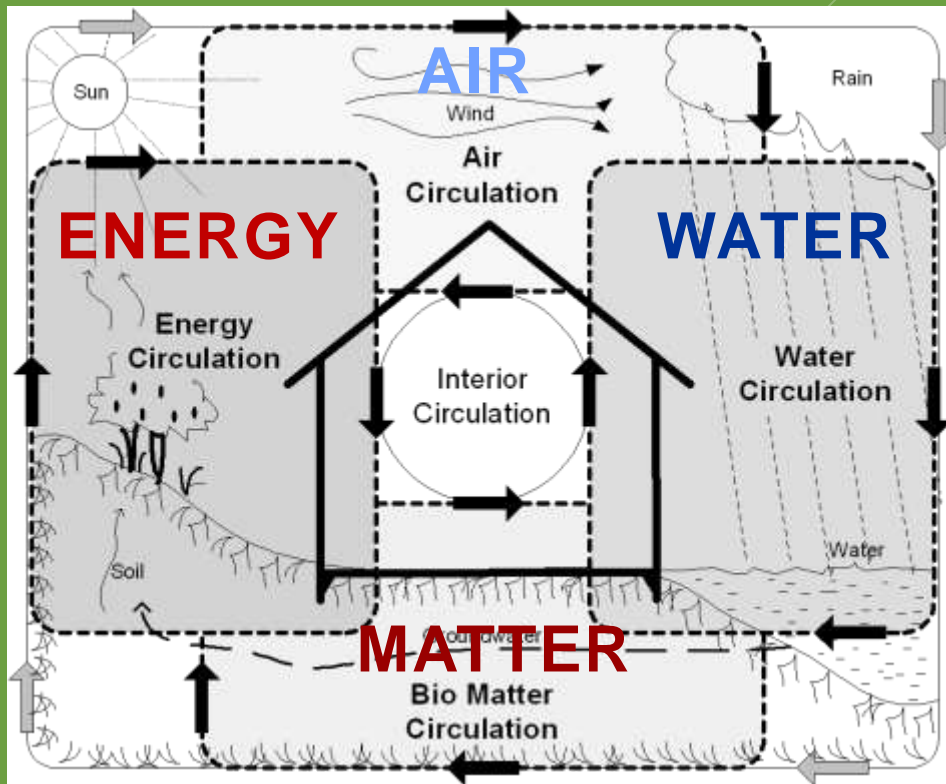
## Precautionary approach

- Take action before something nasty happens – act on what we know



# The Four Elements

The key interrelating elements that Building Biology considers are:



**Air quality**  
animals / plant  
Oxygen & Carbon  
Dioxide cycle



**Water quality**  
water cycle  
purifies and  
energizes water



**Matter / Materials**  
organic forms  
ingest matter  
(minerals),  
decomposition  
returns minerals



**Energy**  
sun's energy  
stored by  
organisms, energy  
release. The  
Electromagnetic  
environment

# Air Quality

Internal air quality depends on outdoor air quality

Indoor can be more than 10 times polluted than outside city air

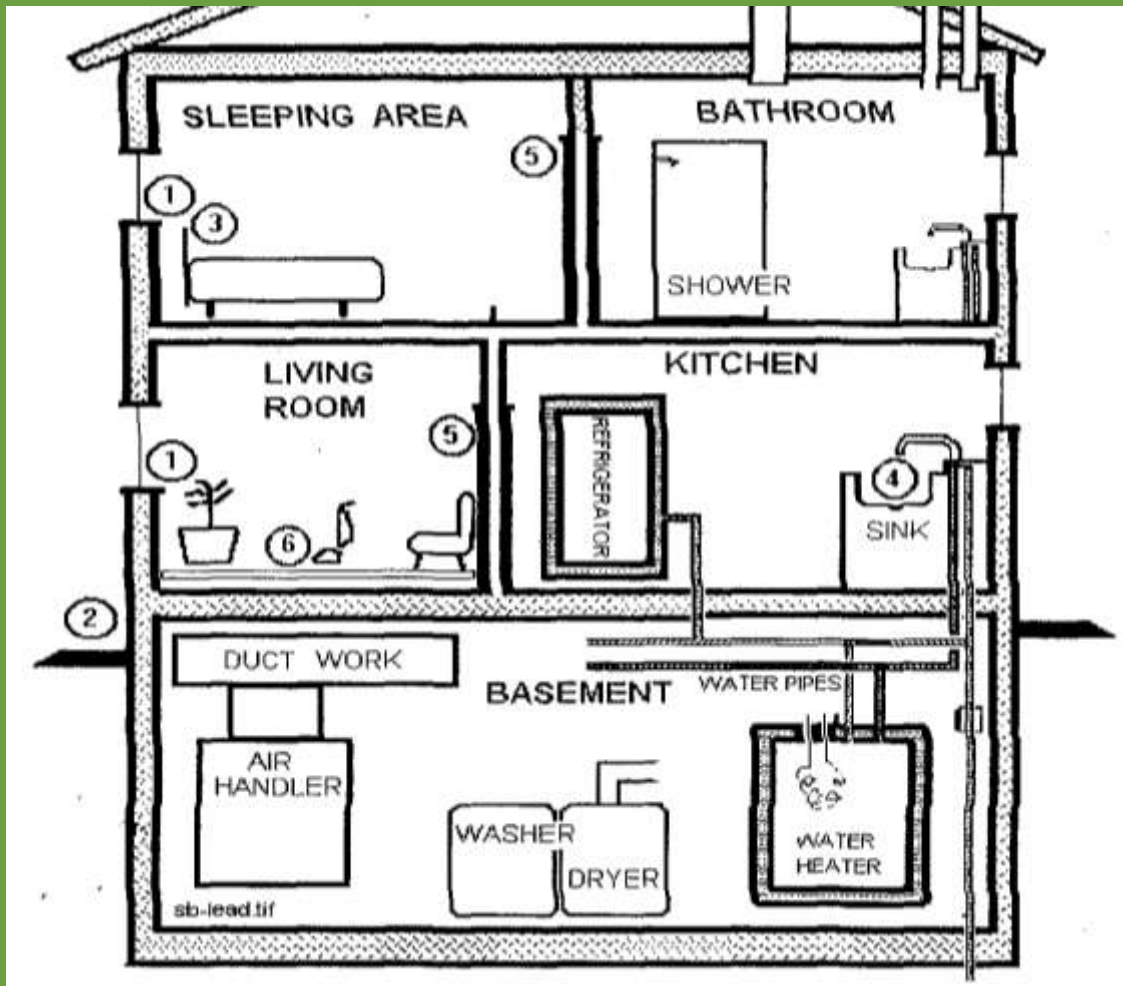
Key contaminants affecting air quality inside buildings:

- Formaldehyde
- Lead – toxic dust
- Moisture control – to prevent mould and bacteria leading to allergies
- Bioaerosols - fungi, bacteria, viruses, dust mites, animal dander, pollen
- VOCs
- Pesticides and herbicides
- Plastics eg PVC
- Radon
- Dust particulates
- Fibres (Asbestos, mineral wool)
- Combustion gases
- CO<sub>2</sub> and Humidity levels

## AVERAGE CONCENTRATION OF COMMON POLLUTANTS IN THE OUTDOOR AND INDOOR AIR



# Lead (Pb)



Contained in various building materials – paints (pre 1979), pipes, solder, crystal decanters  
Particularly an issue in renovation projects

Lead is highly toxic and can be easily absorbed into the body where it accumulates

Can enter the body via:

- inhalation of dust
- absorption via mucosa (fingers and toys)
- Ingestion – water

1. Lead dust from window cill
2. Exterior lead paint chips fall into soil, and affect garden vegetables and water table
3. Children chew on lead painted surfaces
4. Lead pipes and solder leach into water supply
5. Lead dust from window and door jamb friction
6. Peeling lead paint and dust is vacuumed up and re-circulated into the air. Use HEPA type vacuum to prevent dust from re-circulating

Lead test kits

# Moisture Control

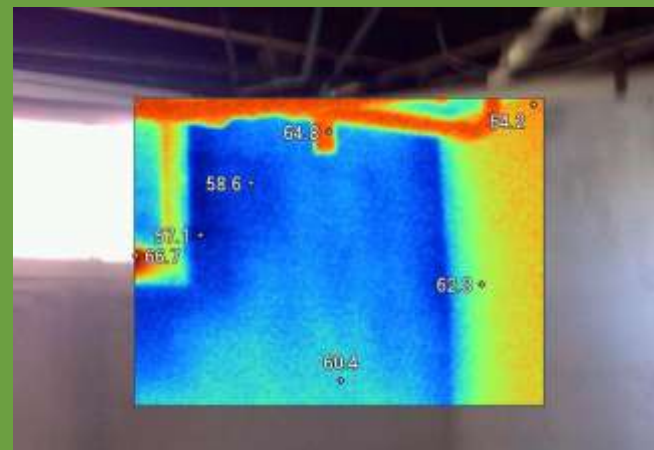
High humidity and moisture damaged building materials create an environment that leads to rapid and continuous growth of mould (mildew) and bacteria

Exposure can result in allergy-like symptoms;

- eye, nose and throat irritation
- headache
- fatigue, and dizziness can result from exposure to these microbiological contaminants

Chronic exposure can lead to:

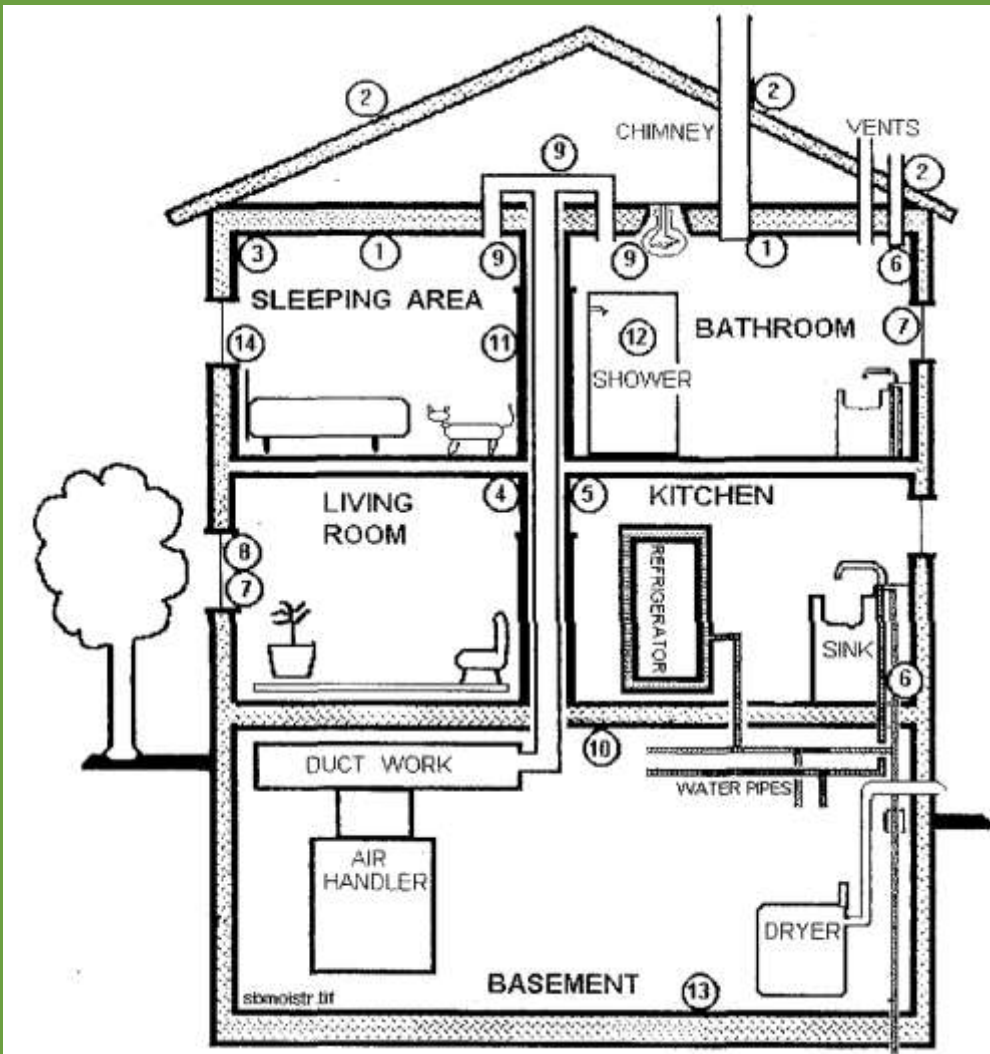
- hypersensitivity
- pneumonitis
- allergic asthma
- chronic allergy symptoms



- Infrared (IR) thermal image
- Evaporative cooling shows wet spots being cooler

# Moisture Control

Indications of problems requiring moisture control



1. Ceiling spotting
2. Roof leaks
3. Damp ceilings at edges near outside walls
4. Mould on walls in heating season
5. Mould on walls in cooling season
6. Damp exterior walls
7. Window condensation
8. Frost or ice on window glass
9. Moisture dripping from light fixtures, heating/cooling outlets and inlets
10. Mould or decay on floor framing
11. Mildew on interior walls or in closets
12. Mildew on bathroom grout, tile and shower curtain
13. Water in basement or crawl space
14. Mould on framing or trim of windows

Mitigation – address moisture problems at source, increase whole house ventilation, use of hygroscopic materials and finishes, moisture permeability (from inside to outside)

# Bioaerosols

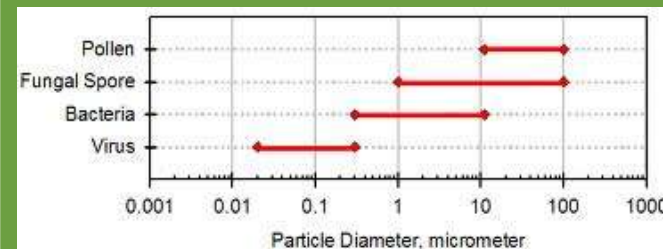
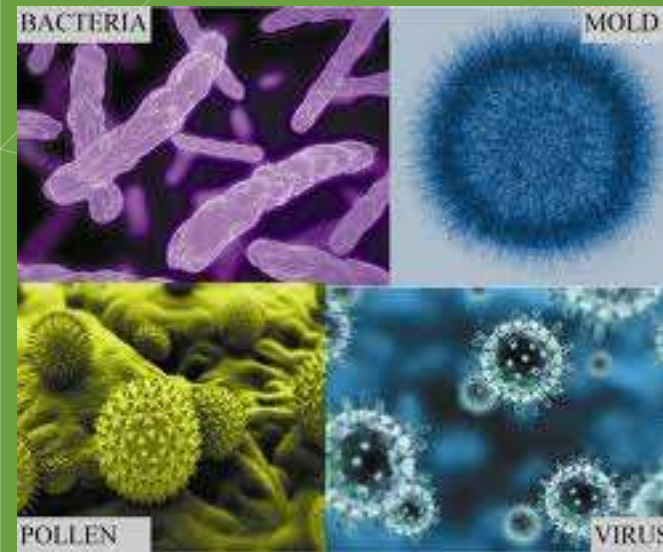
Airborne microscopic particles that are living or that are released from living organisms:

- fungi – mould, mildew, yeast
- animal dander – similar to dandruff
- bacteria
- viruses
- house dust mites (HDM) – faeces and exoskeleton.  
10 week span dust mite will produce 2,000 faecal particles containing digestive enzymes eg: proteases

Implicated in respiratory illnesses, skin allergies, hypersensitive reactions and anaphylactic shock

Infectious diseases linked to indoor aerosol transmission

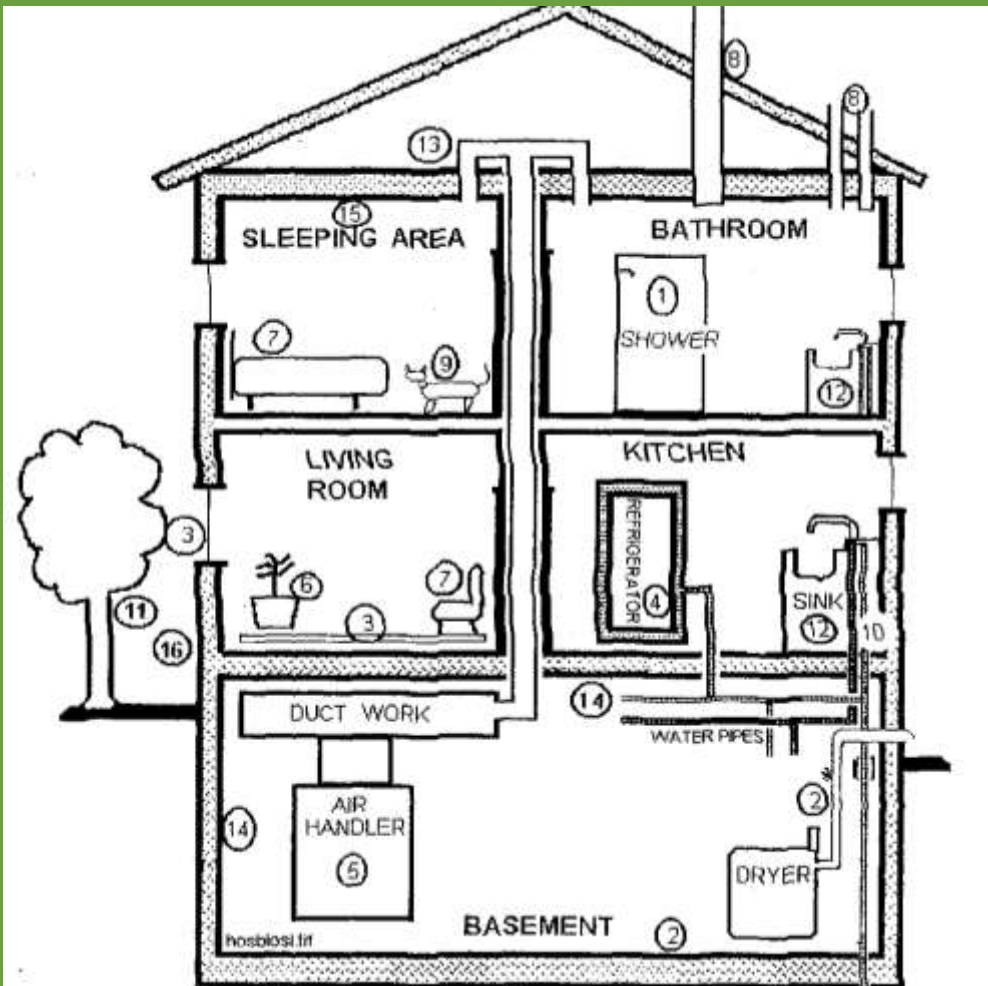
Minute particles can penetrate deep into our bodies when inhaled and flourish if the immune system is unable to adequately deal with them



Bioaerosols in the indoor environment eg: fungal spores

# Bioaerosols

Common Bioaerosol sources for exposure:



## Mitigation:

- keep home clean, well ventilated, damp free and regularly change filters
- microbial organisms cannot tolerate ultraviolet light
- reduce dust mite habitat

1. Moisture behind bath tiles resulting from cracks or caulking gaps
2. High humidity in basement from improper dryer vent, high water table, clogged drain
3. Open windows and wet carpet
4. Drain pan under refrigerator
5. Mould build-up in AC drain pan, cooling coils, and ductwork
6. Mould growth in plant bases
7. Dust mites in fabric – eg: bedding, furniture and carpets
8. When vent flashing leaks, this leads to wet insulation and mold growth
9. Pets and animal dander
10. Water pipe leak leads to mold growth
11. Pollen from local vegetation
12. Dampness and poor airflow under sink leads to mildew and mold build-up
13. Torn or inadequate insulation leads to condensation build-up on AC ductwork, and saturates insulation leading to water stains and mould growth
14. Damp basement walls and ceilings
15. Ceiling damage from roof leaks
16. Trees or shrubs touching building, or near air intake
17. Air and water filters if not regularly changed
18. Washing machines if not regularly disinfected



# Volatile Organic Compounds (VOCs)

Carbon based pollutants, gaseous at room temperature. Examples:

- Acetone
- Benzene
- Formaldehyde
- PCP (Timber treatment, Pesticide)
- Trichloroethylene
- Solvents
- Cleaning fluids
- Pesticides
- Polychlorinated biphenyls (PCBs)
- PVC (eg: binding agents)
- Paint removers



Drager gas detection pump and tube

Health issues:

when we inhale VOCs they:

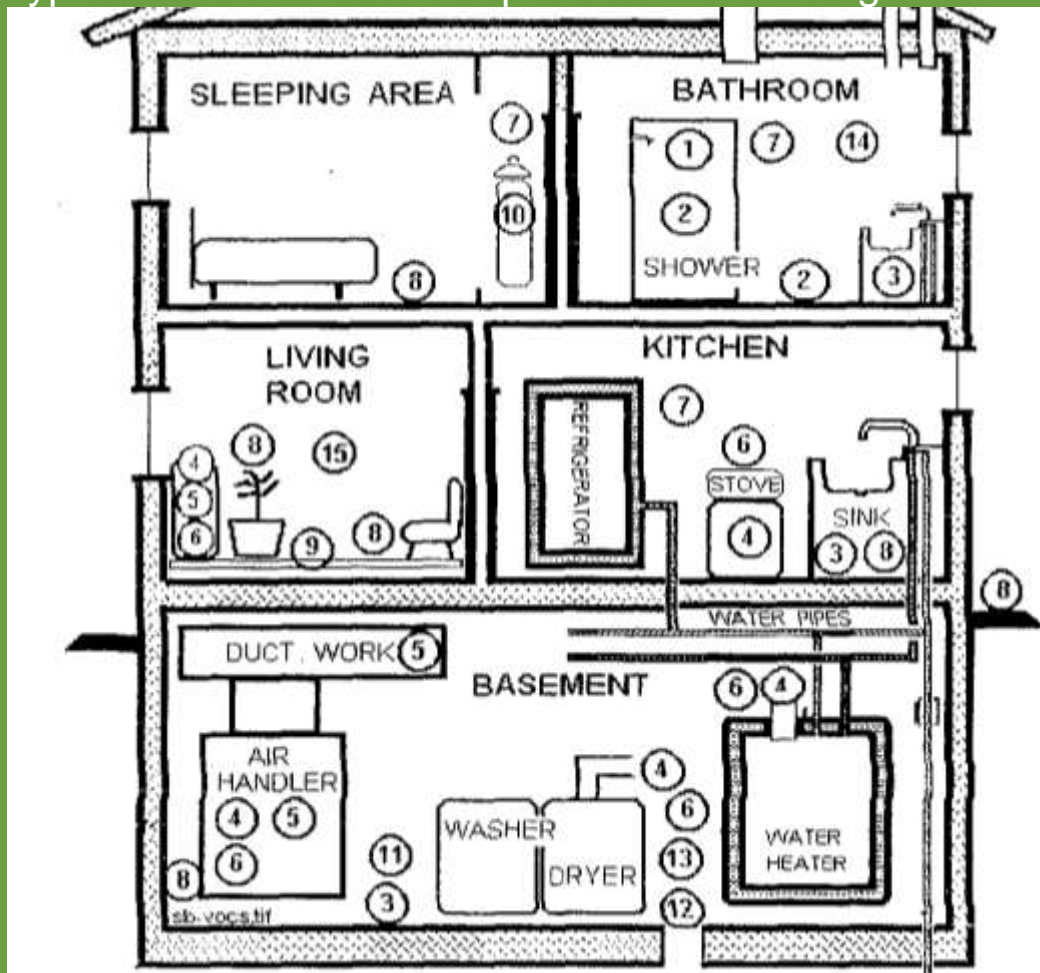
- affects almost every system in the body
- have been found in every organ of the body

Symptoms:

- headaches
- mild respiratory problems
- asthma
- concentration and memory problems
- Cancer
- Birth defects
- CNS disorders
- Mutagenic effects
- Hormones mimicking
- Brain damage
- Multiple Chemical Sensitivity (MSC)
- Organ damage
- Organ failure

# VOCs

Types and sources of compounds in a building:



Mitigation:

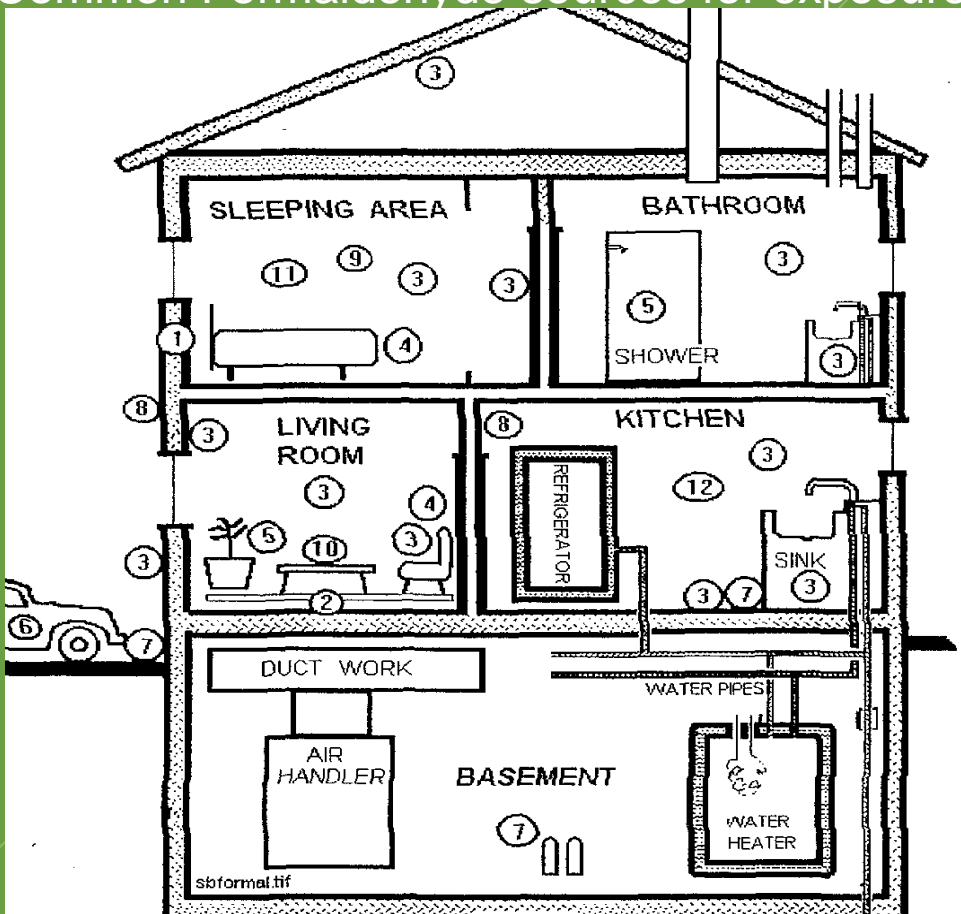
- Identification and removal of problematic materials
- Sealing off offending materials
- Use of absorbent air filters
- Wash down surfaces (eg: baking soda vinegar)
- Allow close proximity of plants

1. Chlorine treated water in hot shower water produces chloroform
2. Tile adhesives and grouts off-gas
3. Aerosol sprays use 1, 1, 1 – Trichloroethane as propellants
4. Unvented gas stoves, heaters, and furnaces produce Nitrogen Oxides
5. Fumes from finishes on new heaters and appliances and ductwork
6. Hydrocarbons from faulty vented / improperly adjusted boilers, stoves, heaters, clothes dryers, grills, gas refrigerators and fireplaces (not organic)
7. Cleaning supplies, air fresheners, moth balls off-gas Para-dichlorobenzene
8. Pesticides off-gas chemical vapors
9. Synthetic carpets, plastics, carpet pads off-gas styrene, formaldehyde and other VOC's
10. Dry cleaned clothes off-gas Tetrachloroethylene, Perchloroethene
11. Paint strippers, paints, thinners: Methyl chloride and others
12. Methane and other sewer gases
13. Fuel in cans: Propane, Gasoline, Benzene, etc.
14. Cosmetics: Perfume, cologne, etc.
15. Office machines: Laser printers, copiers, etc.: Zylene, Ozone & others

# Formaldehyde (HCHO)

- Very prevalent VOC
- Upper respirator irritation at low levels
- Chronic exposure can lead to MCS (Multiple Chemical Sensitivity and linked to Leukaemia development)

## Common Formaldehyde sources for exposure:



1. Urea formaldehyde foam insulation (UFFI) used extensively in the 1970's. Still off-gassing in some homes.
2. Carpeting and foam carpet pads.
3. Particleboard, chipboard, MDF, paneling, plywood, drywall and drywall compound: used in cabinets, furniture, roof and wall construction.
4. Foam and fabrics used in some upholstery.
5. Caulking and adhesives
6. Automobile interiors
7. Pesticides
8. Latex (water based) paint and drywall
9. Cosmetics
10. Inks: Paper, etc.
11. Dyes: Cloth, materials, laundry pre-spot, wrinkle treatment, etc.
12. Preservatives: Wood, Wallpaper, etc

Health warning by Royal College of Obstetricians and Gynaecologists – Chemical Exposure During Pregnancy (Scientific Impact Paper 37) May 2013)

Mitigation: Avoid or remove

# Pesticides & Herbicides

## Biocide

- Generic names for chemicals used to kill living organisms (pesticide, insecticide, herbicide, rodenticide, etc)
- Over 4 billion pounds of biocides are used annually in North America
- Also effect other organisms other than the target
- Can effect humans especially children and people with compromised immune systems
- Target pests can become immune

## Health issues:

- Continued use creates accumulative toxic build up that can break down very slowly & last years
- Acute or chronic exposure can have very damaging affects on mammals, birds and fish
- Risk depends on toxicity and level of exposure

## Affects:

- Immune and central nervous systems
- Mutagenic
- Carcinogenic
- Teratogenic (birth defect causing)

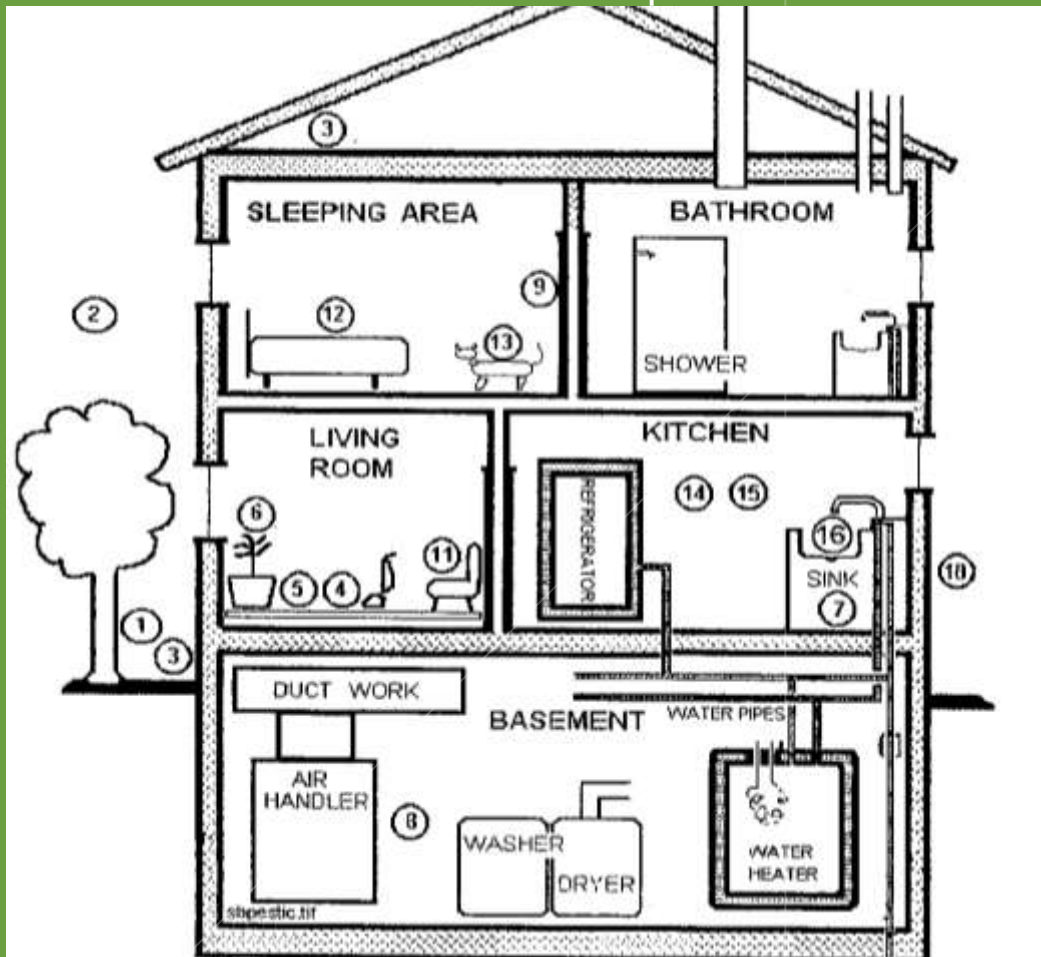
Biocides find their way into soil, water, air, crops and even breast milk

Difficult and expensive to detect



# Pesticides & Herbicides

Common Pesticide sources for exposure:



Mitigation:

- Avoid use
- No shoes policy indoors – shoe tracking one of the primary contamination methods
- Actively remove if experiencing acute sensitivity
- Move if you cant sort it (its really not worth being poisoned)

1. Lawn and shrub treatment
2. Drift from neighbour's pesticide spraying
3. Insecticide treatment by spraying
4. Vacuum cleaner dust spread around containing pesticides
5. Pesticide residue in carpets from pest control applications, both inside and tracked in on shoes
6. Pesticides used on houseplants
7. Spray chemicals stored under kitchen sink
8. Spray chemicals stored in basement
9. Biocides used in paints to prevent mold and mildew
10. Pressure treated wood
11. Biocides on fabrics – furniture
12. Biocides on fabrics – cloth (linen or clothing)
13. Pet treatment for fleas, etc.
14. Insect repellent evaporating solids
15. Pesticide residues in food and in drinking water
16. Treatment of sheep wool (Permethrin, EULAN)

# Genesis Project – refurbishment multi-use community building, Devon



## Air quality

- non toxic fungal removal – use of hounds for detection
- low VOC
- natural ventilation
- reduced dust mite habitat
- Non biocides

## Matter

- Recycled materials
- low embodied energy
- natural, vapour permeable
- minimise PVC

## Water - low water use

## Energy

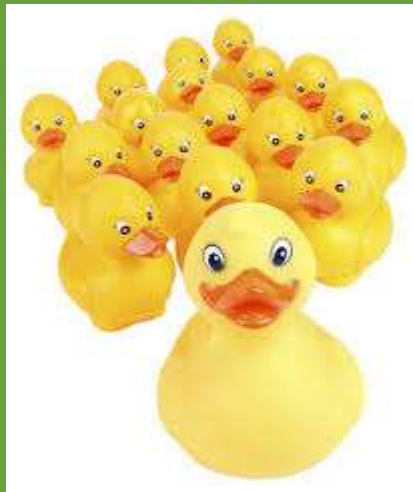
- low energy passive design
- natural daylight design

# Plastics

Phthalates commonly used

- as plasticisers majority in PVC (58% of all PVC used in construction)
- in personal products such as perfume, soaps, deodorants, creams, etc

Di(2-ethylhexyl) phthalate (DEHP) manufactured chemical commonly added to plastic to make them flexible



DEHP is a colourless liquid with almost no odour

Used in plastic as:

- wall coverings
- table cloths
- floor tiles
- furniture
- upholstery
- shower curtains
- garden hoses
- swimming pool liners
- rainwater goods
- nappies
- toys
- shoes
- car upholstery
- packaging film
- wire sheathing
- medical tubing
- storage bags
- etc

# Plastics

## Health issues of PVC

### Manufacturing

- Workers exposed to vinyl chloride gas and dioxin
- Off-gassing DEHP

### In use

- Off-gassing DEHP

### Disposal

- when burnt releases dioxin, hydrogen chloride (HCl) and other organochlorine products as well as emitting heavy metals

DEHP is linked to:

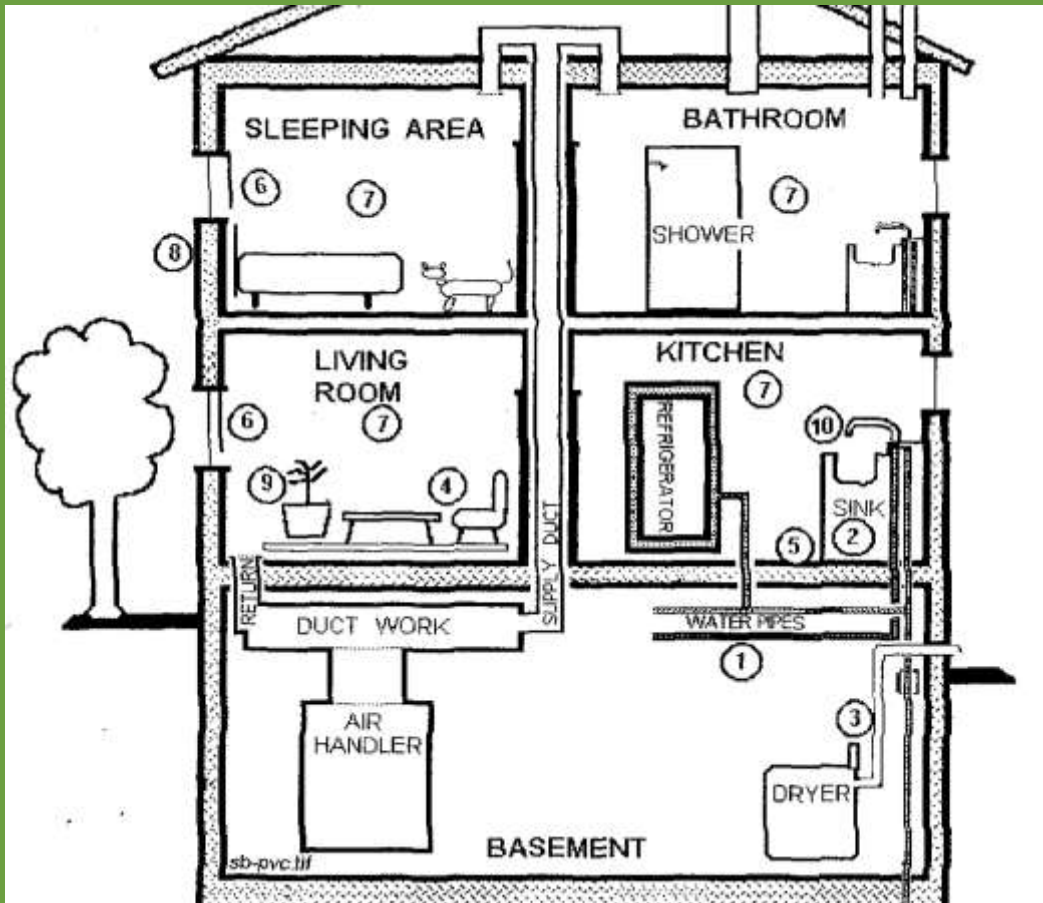
- Asthma
- Mimics hormones





# Plastics

Common Household items made of PVC:



1. Water pipes
2. Sewer pipes
3. Ductwork
4. Furniture
5. Floor coverings
6. Electrical installations, wire etc
7. Curtains and blinds
8. Wallpaper
9. Miscellaneous, knickknacks, etc.
10. Containers, grocery sacks, plastic wrap

Phthalates commonly used in personal products such as perfume, soaps, deodorants, creams, etc

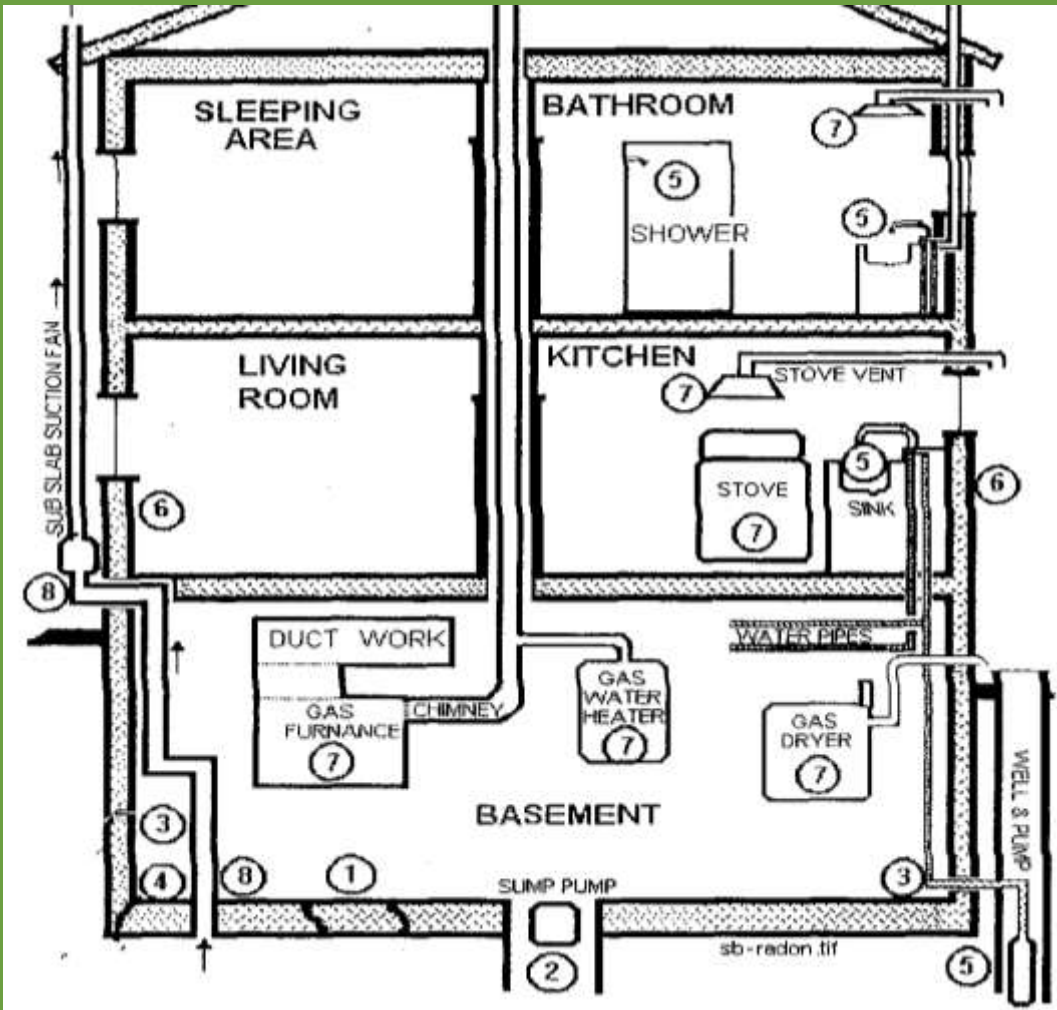
Mitigation: Avoid chlorine based materials

- Avoid plastics that are flexible, sticky and/or smell
- Use of natural materials or if they must be synthetic then use PE (Polyethylene) or PP (Polypropylene) instead
- Replace plastic materials with natural materials especially in the bedroom



# Radon

Items to check after Radon results are high:



Mitigation:

- Radon can be reduced by ventilation (passive or active)
- sealing the soil contact areas of the house (items 1-4) and introducing a ventilated Radon sump

Naturally occurring odourless, radioactive soil gas from decaying uranium

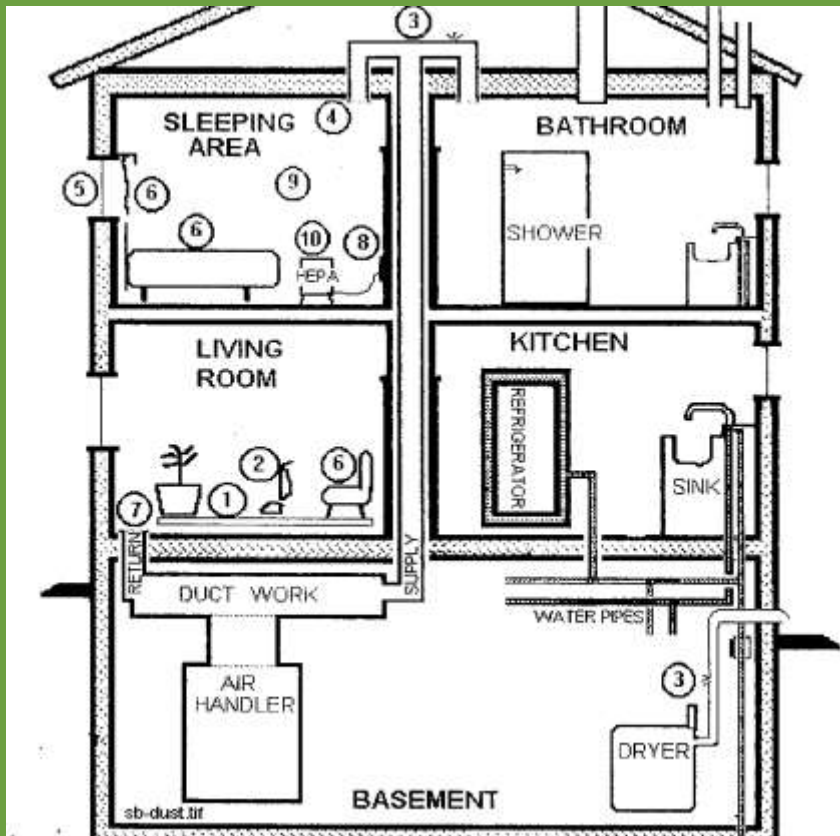
Causing lung cancer second only to cigarette smoking

1. Cracks in the concrete slab
2. Exposed soil in sump pump pit should be sealed)
3. Cracks in basement walls
4. Cracks at floor and wall joints
5. Radon in water from a well
6. Building materials such as some granite
7. Exhausting ventilation (Gas furnace, water heater, dryer, stove, and exhaust fans) causing negative pressure in the building drawing the radon in
- 8.



# Dust & Particulates

Items to check for dust and particulate issues:



Damaging particulates such as radon, lead and cigarette smoke attach to dust

1. Carpeting
2. Vacuuming exhaust
3. Leaky ductwork
4. Leaky vent collar
5. Environmental dust
6. Bed clothes, materials and furniture (fabrics)
7. Return vent for heating and air conditioning (HVAC) system
8. Leaks around switch plates
9. Positive pressure in attics and wall cavities with negative pressure in living spaces
10. Free standing HEPA filter

Mitigation:

- reduce particulate forming activities and materials (eg: smoking, photocopiers, foam upholstery)
- remove plastic materials eg: carpeting to reduce electrostatic effects
- clean using damp mop / duster
- use HEPA vacuum (High-Efficiency Particulate Air) (standard vacuums only trap dust over 10 microns)
- Vent fireplaces, stoves and gas appliances
- sealing and insulation of building (17°C surface temperatures)
- increase ventilation or point source removal



# Malthouse Cottage – Hampshire



## Air quality

- low VOC
- natural ventilation
- reduced dust mite habitat
- non biocides
- radon barrier

## Matter

- low embodied energy
- natural, local, vapour permeable
- minimise PVC

## Water - low water use

## Energy

- low energy passive design
- natural daylight design





# Neely House – refurbishment, Cambridge



## Air quality

- low VOC
- natural ventilation
- reduced dust mite habitat
- non biocides, radon barrier

## Matter

- low embodied energy
- natural, vapour permeable
- minimise PVC

## Water - low water use

## Energy

- low energy passive design
- natural daylight design
- radial wiring with shut off circuits in bedrooms



# Water Quality - contamination

Contamination of mains water entering building:

- Microbial
- Inorganic (includes lead, asbestos)
- Organic (Nitrates)
- Biocides (eg: pesticides and herbicides)
- Radionuclide (includes radon 3.5 dayhalf life to polonium)
- Chlorination and fluoridation

Contamination whilst in building:

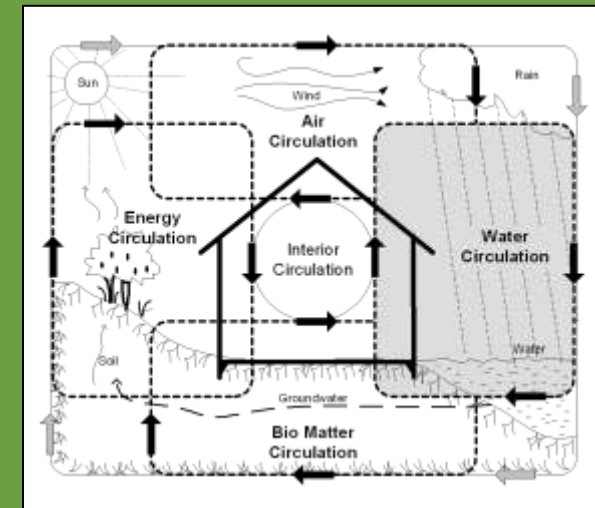
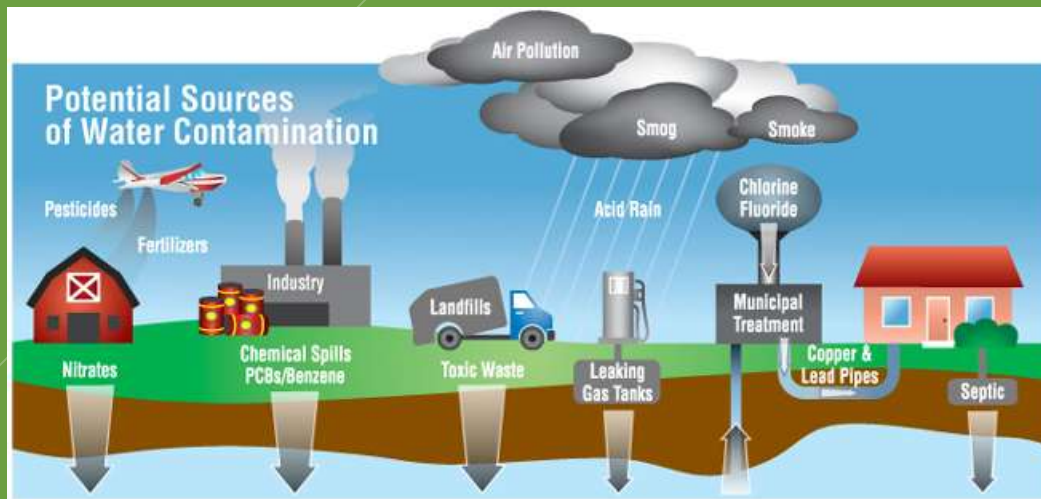
- Pumps, faucets containing brass or lead
- Pipe material – copper, plastic, lead solder

Bottled water contamination:

- Bacteria
- Chemicals from plastic containers
- Chemicals from the treatment process

Chlorination and fluoridation:

- targets bacteria, particulates and various chemicals
- produces disinfection by-products, or trihalomethanes (THM's) eg: chloroform
- linked to range of ailments from asthma, eczema, to bladder cancer, heart disease



# A summary of Treatment Technologies:

Method	Uses	Limitations	Comments
Distillation	kills all microbes by heat removes heavy metals and nitrates often used in combination with activated carbon filters	<ul style="list-style-type: none"> <li>can remove only chemicals (like fluoride, iron or nitrates) with a higher boiling point than water</li> </ul>	needs regular de-scaling and weekly disinfecting with bleach or heat Reduced mineral content in drinking water (health issue) can concentrate chemicals with boiling points lower than water in distilled water (like ammonia)
Ultra-Violet	kills bacteria and viruses	<ul style="list-style-type: none"> <li>needs filtration to remove microbes embedded in dirt particles, including parasites</li> </ul>	needs very fine, 5 micron pre-filter and, slow water flow; UV lamp must be kept clean
Chlorination	kills bacteria and viruses can be used to remove some forms of iron, as long as water is filtered after chlorination	needs filtration to remove microbes shielded or embedded in dirt particles, including parasites	needs careful handling of chlorine, testing of chlorine levels, and maintenance of dosing pump
Ozonation	<ul style="list-style-type: none"> <li>kills most microbes, but not cryptosporidium</li> <li>removes organic compounds, including pesticides</li> <li>can be used in combination with activated carbon filters</li> </ul>	needs filtration to remove microbes embedded in dirt particles, including parasites	<ul style="list-style-type: none"> <li>varies in effectiveness depending on application and manufacturer</li> <li>contact your local <a href="#">public health unit</a> for more information</li> </ul>
Activated Contactors	Carbon remove small amounts of some chemicals used for removing tastes and odors, and reducing trace levels of organic chemicals (like pesticides)	are not suitable for removing minerals, or larger amounts of chemicals	<ul style="list-style-type: none"> <li>must be replaced regularly but hard to know when contactors are exhausted</li> <li>can become a dangerous source of bacteria and taste and odor problems</li> </ul>
Filters	use ceramic candle filters to remove bacteria and parasites, but not viruses use other filter types to remove sand, sediment, rust and particles use specially rated filters to remove very small particles	need chlorination in addition to ceramic candle filters to remove viruses	<ul style="list-style-type: none"> <li>need regular maintenance and replacement for proper operation</li> <li>Can become a source of bacteria</li> </ul>
Greensand Treatment	<ul style="list-style-type: none"> <li>removes moderate amounts of iron and manganese</li> </ul>	is unsuitable for removing microbes	is not easy to operate or maintain needs regular backwash and periodic reactivation with permanganate solution and/or bleach
Reverse Osmosis	<ul style="list-style-type: none"> <li>removes nitrates, sulphate, hardness, most microbes, dirt particles and small amounts of some pesticides</li> </ul>	can result in plugged membranes because of hard water	<ul style="list-style-type: none"> <li>is costly because of need to replace membrane</li> <li>needs prefiltration and softening of hard water</li> <li>Reduces mineral content (health issue)</li> </ul>
Softeners	<ul style="list-style-type: none"> <li>reduce hardness that produces lime deposits on dish-washed items, and gives a starched effect on laundry</li> </ul>	are not suitable for removing microbes or most chemicals increase sodium concentration in treated water	need periodic replacement of softener salt and disposal of concentrated salty water



# Water filtration

Drinking tap

Options for current domestic project

1. Particle filter under sink with carbon filter
  - filters – chlorine, THMs, pesticides, herbicides, industrial solvents, discolouration, particles (rust etc), benzene, petroleum solvents, oil residues
  - does not filter – nitrate, fluoride, heavy metals or bacteria
  - £67, replacement filter £16 every 6 months
2. Particulate filter under kitchen sink with 1 micron ceramic filter
  - filters – as 1. above + heavy metals and fluoride, some bacteria eg: Ecoli, Salmonella Typhi, Shingella
  - £91, replacement filter £39 every 6 months
3. In line ceramic filter
  - requires plumber to fit but can use existing kitchen tap
  - filters – as 2. + arsenic, trace heavy metals, lead, mercury, iron, magnesium, aluminium, copper
  - £60, replacement filter £60 every 12 months requiring a plumber to fit



1



2



3

# Water filtration

## Whole House ceramic filter:

- Requires a plumber to install
- Can use normal kitchen tap
- Filters water to all points including showers
- Filters as 3.
- £365 capital cost
- Replacement every 2 years £365 (£165 per year)



# Woolsey Sports & Community Hall – Devon



## Air quality

- low VOC
- natural ventilation with wind catchers
- reduced dust mite habitat
- vapour permeable construction
- non biocides, radon barrier

## Matter

- low embodied energy
- Natural & local
- vapour permeable
- minimise PVC

## Water

- rainwater collection
- low water use

## Energy

- low energy passive design
- solar pv & wind turbine
- natural daylight design
- ground source heat pump





# Matter

Materials selection criteria:

1. Natural Occurrence (NO) – naturally available
2. Ecological Impact (EI) – cradle to cradle approach
3. Energy Consumption (EC) or embodied energy
4. Health Impact (HI) – cradle to cradle approach
5. Out or off-gassing toxic substances (OG)– impact on quality of air
6. Diffusion and Breathing (DB) – the third skin approach
7. Hygroscopicity (HG) – ability to absorb water and release it

Building Biology gives materials a rating scale 0 – 3

rating – 0 the most negative  
eg: clay = 3, bricks = 2 and PVC = 0



## Embodied energy

Timber - 110 kWh/m<sup>3</sup> =  
x1 energy unit

Brick x4

Cement x5

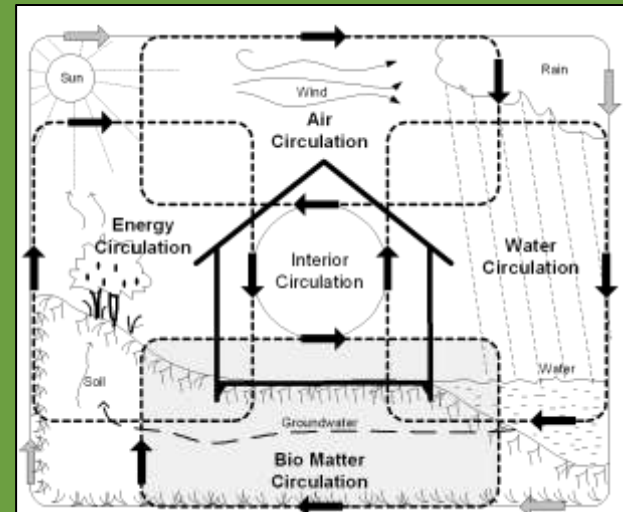
Plastic x6

Glass x14

Steel x24

Aluminium x126

Lead x300+



<b>Material - finishes eg: for refurbishment of existing buildings</b>	<b>NO</b>	<b>EI</b>	<b>EC</b>	<b>HI</b>	<b>OG</b>	<b>DB</b>	<b>HG</b>	<b>Avg</b>
<b>Floor Coverings</b>								
1. Carpeting								
Synthetic	0	0	0	0	0	0	0	0
Natural	3	2	2	1	3	3	3	2.42
2. Hardwood Floor								
Solid wood	3	2	3	3	3	3	3	2.86
3. Ceramic Tile								
Unglazed tiles	2	2	2	3	3	1	1	2.0
Glazed tiles	2	1	1	3	3	0	0	1.43
4. Natural Linoleum								
Natural linoleum	1	2	2	3	2	2	2	2.0
Cork floor tile	2	3	3	3	3	3	3	2.86
5. PVC (Vinyl)								
Vinyl	0	0	0	0	0	0	0	0
Vinyl with asbestos	0	0	0	0	0	0	0	0
<b>Wall Coverings</b>								
1. Wallpaper								
Paper	2	1	3	2	2	3	3	2.28
Vinyl	0	0	0	0	0	0	0	0
2. Paint								
Natural paint	2	2	2	2	2	2	2	2.00
Synthetic paint (toxic)	0	0	1	0	0	0	0	0.14
<b>Wall Substructures</b>								
1. Drywall (sheetrock)								
Natural gypsum	3	2	2	2	2	2	2	2.14
"industrial gypsum"	0	0	0	1	2	2	2	1.00
2. Wood composites								
Particle board	1	2	2	0	0	1	2	1.14
Plywood	1	1	2	1	1	0	2	1.14
3. Plaster								
Lime plaster	2	2	2	3	3	2	3	2.42
Cement plaster	1	0	1	1	3	1	2	1.28
4. Wall insulation								
Fibreglass	0	1	0	0	0	1	0	0.28
Natural fibers	3	3	2	2	2	3	3	2.57
<b>Windows</b>								
1. Window frames								
Wood frames	3	2	2	3	3	3	3	2.71
Vinyl frames	0	0	0	0	0	0	0	0
Metal frames	2	1	0	1	3	0	0	1.00
2. Glass								
Clear glass	0	1	0	3	3	0	0	1.00
Colored glass	1	1	0	1	3	0	0	0.71

# Trelowarren

New build and refurbishment, Grade 1 Listed buildings and Landscape. Leisure facilities, Lizard Peninsula, Cornwall



## Air quality

- low VOC
- natural ventilation
- reduced dust mite habitat
- non biocides, radon barrier

## Matter

- low embodied energy
- natural, vapour permeable
- minimise PVC

## Water

- well water filtration
- low water use

## Energy

- low energy passive design
- wood chip district heating
- natural daylight design
- radial wiring with shut off circuits in bedrooms



# Torrington Vision

infants and junior schools, early learning, children's centre, college



## Air quality

- low VOC
- natural ventilation with wind catchers
- reduced dust mite habitat
- vapour permeable construction
- non biocides, radon barrier

## Matter

- low embodied energy
- natural, vapour permeable
- minimise PVC

## Water - low water use

## Energy

- low energy passive design
- cool larder
- solar thermal
- natural daylight design





# RHS Rosemoor Centre for Learning



- Flexible learning inside and outside spaces
- Sensitive site
- Designed to a budget
- Low environmental impact
- Healthy buildings & Permaculture design principles







# Energy - Electro-Magnetic Radiation (EMR) pollution

What is EMR?

All matter produces electromagnetic energy

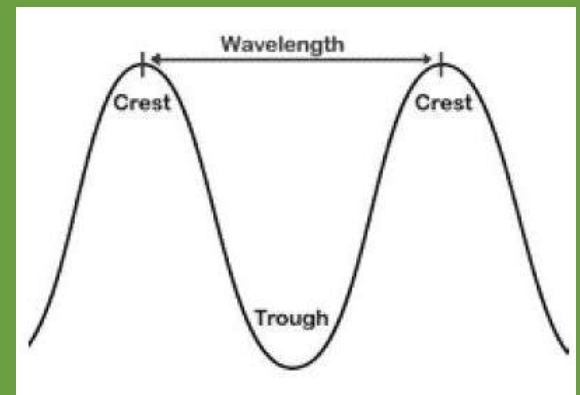
Radiation climate is an integral part of everyday living

- EMR is given off in many different forms, which all share one fundamental property: *the electrical charge*
- The various manifestations of EMR differ only in the *frequency* and *wavelength*
- EMR can be seen either as a continuous wave or as discrete particles

**Alternating wave** – is a magnitude crest followed by a trough, and then a crest and so on

**Frequency** – the number of cycles, from one crest to the next crest, per time, usually expressed in Hertz (Hz)

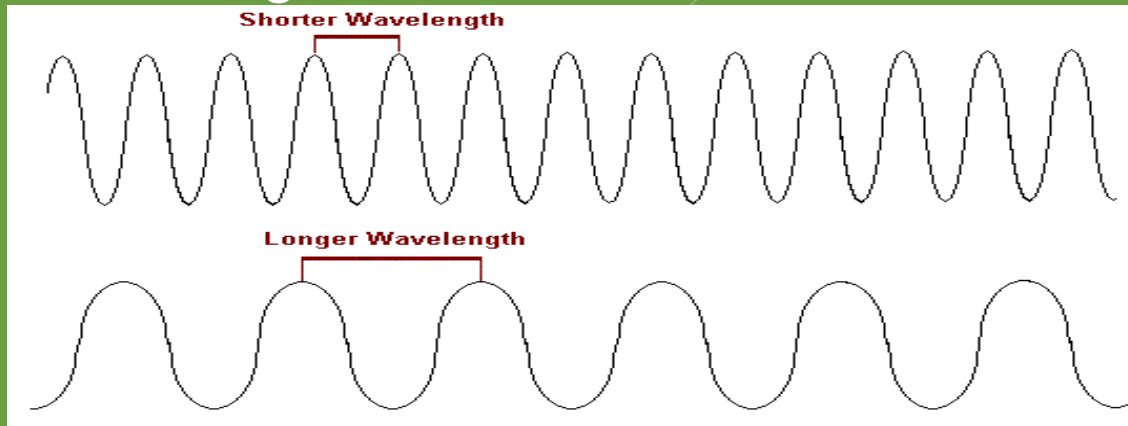
**Wavelength** – distance from crest to crest of an alternating wave



# Energy - Electro-Magnetic Radiation (EMR) pollution

What is EMR?

The higher the frequency, the higher it's energy and the shorter the wavelength



When a frequency of a given radiation becomes so high that the released energy is sufficient to form ions in matter it is passing through,

we speak of ionizing radiation

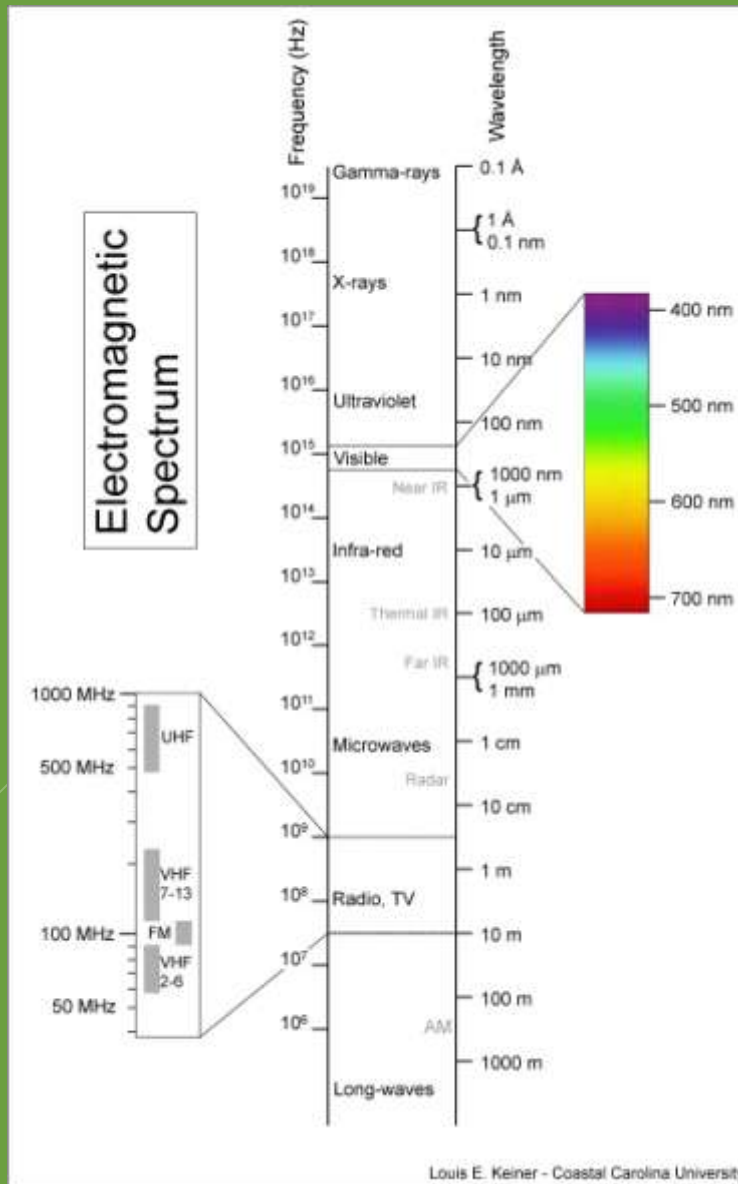
# Electromagnetic Spectrum

The toxic effect of ionizing radiation is well understood

Our atmosphere protects us from natural ionizing radiation from the sun

Non ionizing EMR also has detrimental biological effects even at very low exposure levels

The Biological effects of non ionizing EMR is not so readily understood



## Divided into 4 major Sections:

### Ionizing radiation

Most energetic (ionizing) radiation including x-rays and cosmic rays generated when charges inside certain atomic nuclei being transformed

### Non-ionizing radiation

Visible light

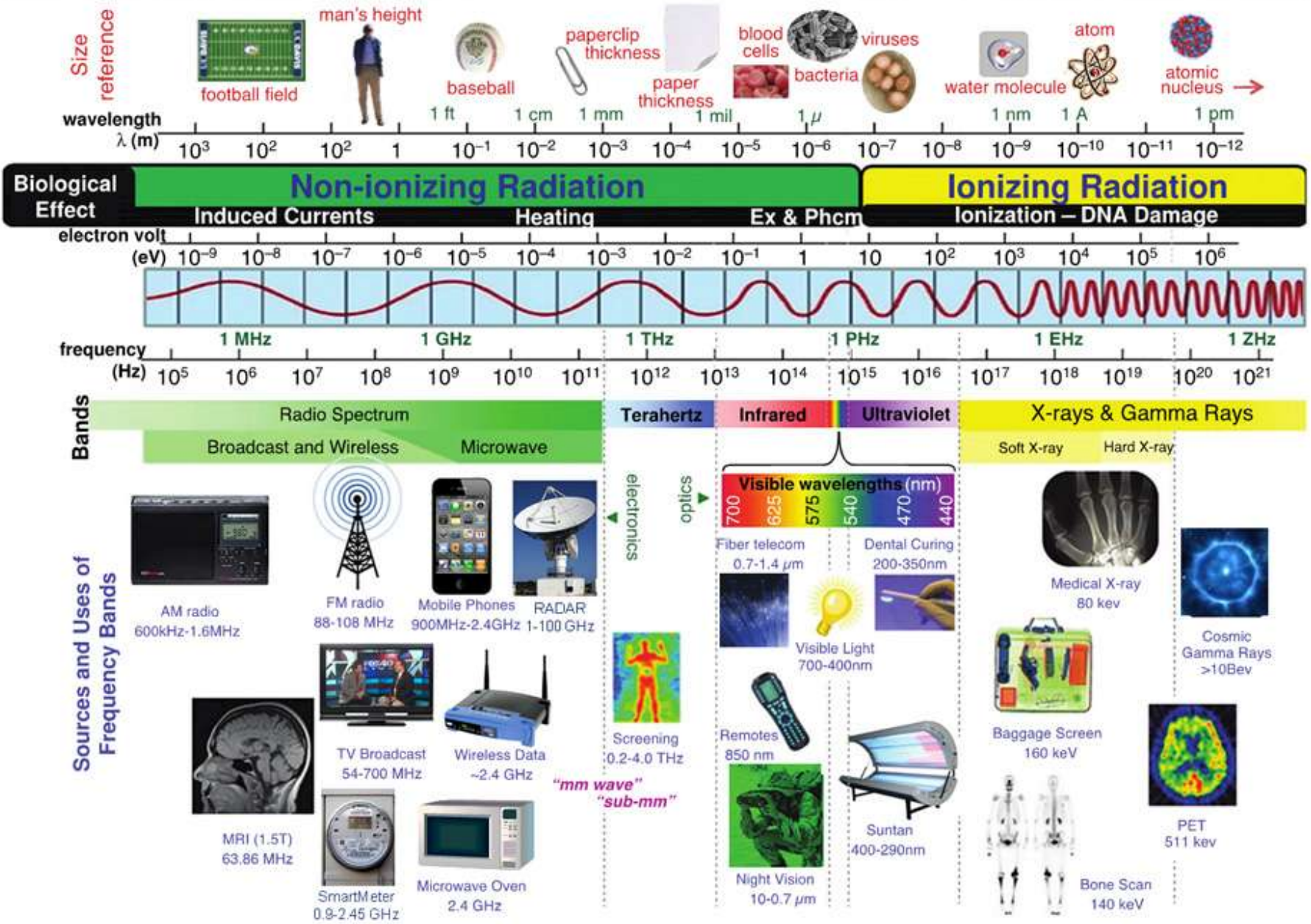
### Non-ionizing radiation

Electrical charges associated with rotations and vibrations of molecules

### Non-ionizing radiation

Electrical charges as freely moving electrons

# ELECTROMAGNETIC RADIATION SPECTRUM



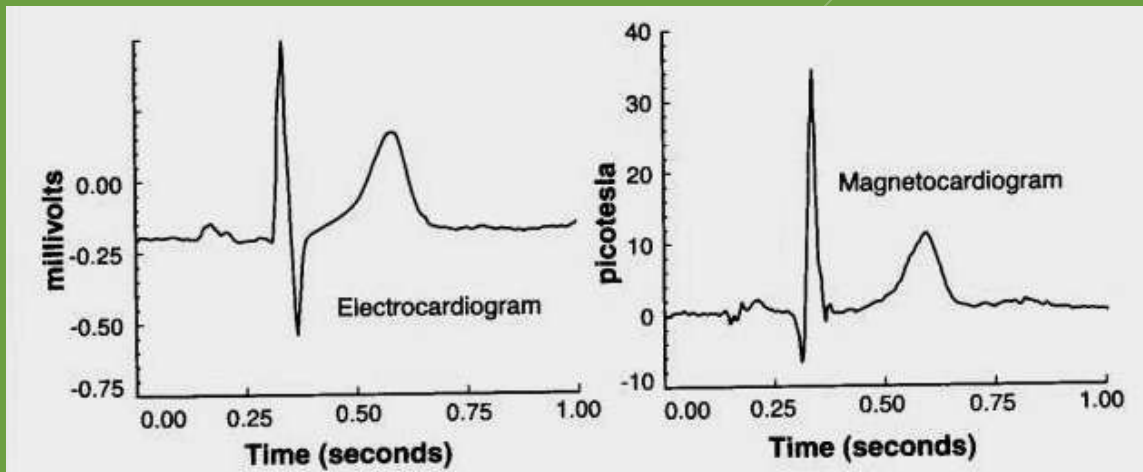
Building Biology focuses on non-ionizing radiation issues



# Health effects of EMR

## Pulses

Communication within our body was traditionally thought only through ionized (electrical) currents driven by pulsed signals from the heart and the brain



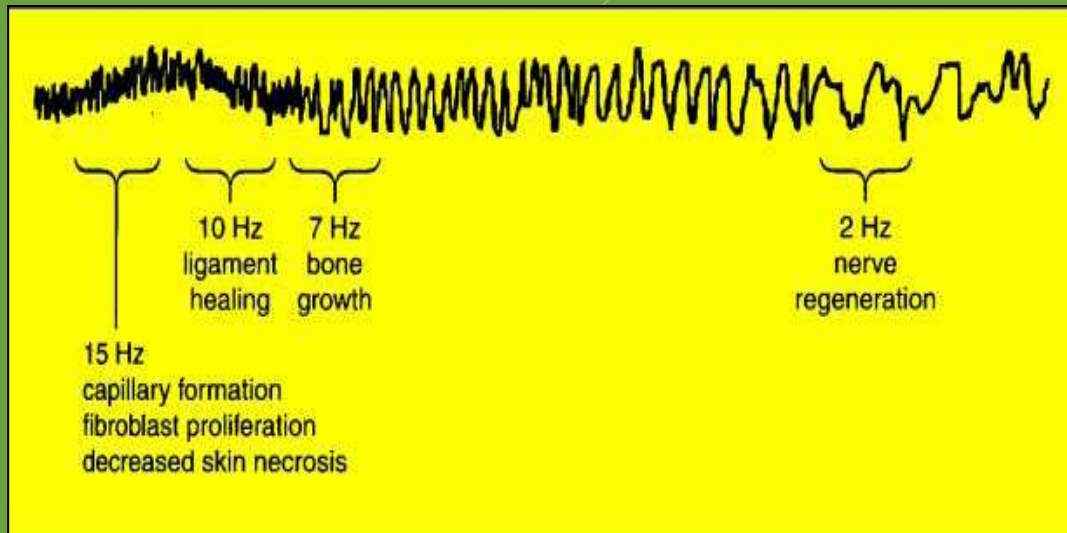
External EMR impulses can obscure these signals ie: are background 'noise'

# Health effects of EMR

We now understand that in addition our bodies also communicate via:

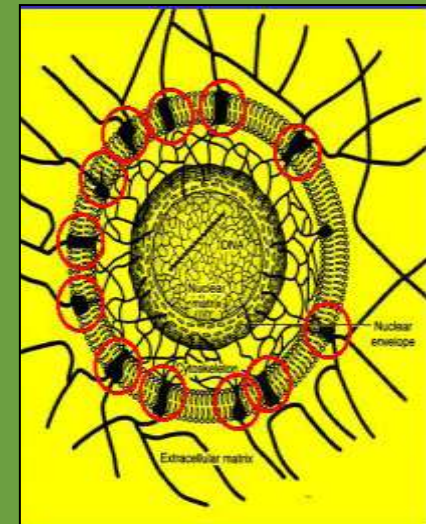
## Vibration

- Our bodies also communicate at a cellular level through vibration
- Human cells vibrate at a range from 0 – 75Hz



## Semi-conductive

- Human communication system is *also* semi-conductive (electronic) via highly complex fibrous membranes



Vibrations and semi conductors are highly influenced by external EMR

# EMR - What is the problem?

Humans have evolved with natural EMR sources

- Most natural EMR is needed to maintain good health

Man-made EMR has increased over last 100 years

- man-made EMR can interfere with biological systems causing electromagnetic stress to our bodies

Biological problems associated with man-made electromagnetic stress:

Brain - increase permeability of the blood **brain** barrier

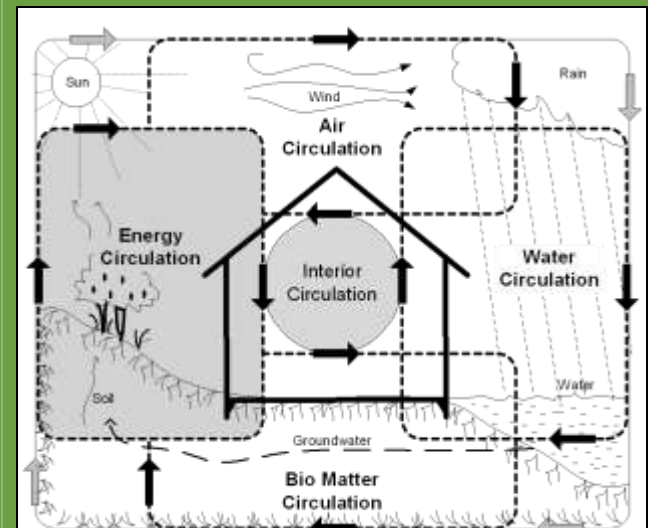
- Behavioural abnormalities
- Learning disabilities
- Altered bio-cycles
- Stress responses

Growing issues

- embryos
- genetics
- cancer

Building Biology focuses on the biological effects of electromagnetic radiation

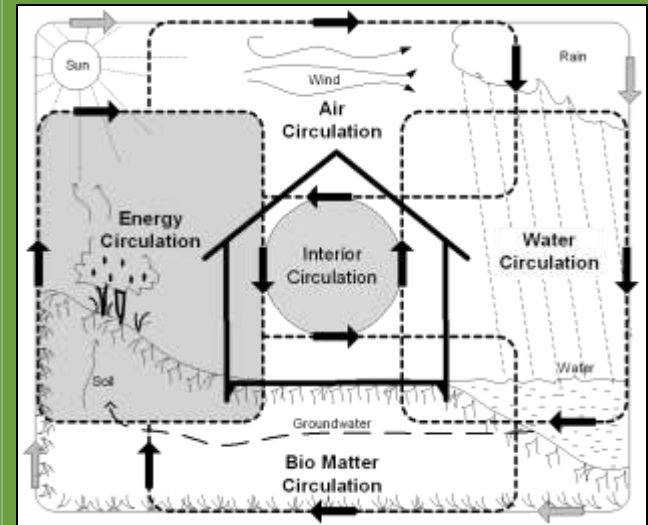
- brain waves
- heart beat
- nerve signals



# Electromagnetic Radiation (EMR)

Common electromagnetic pollution found in indoor environments:

- Alternating low frequency electric fields
- Alternating magnetic fields
- High frequency electric fields (Radio, WLAN (wifi), mobile phones, cordless phones, microwave ovens)
- Electrostatic fields
- Static magnetic fields
- Radioactivity
- Light – natural electromagnetic fields



# EMR Safety Guidelines

50/60z (High Voltage Power Lines, Home Electrical Wiring, Power Cords, Appliances)

Location	Reference	Limit Based On	AC Magnetic Field mG	AC Electric Field V/m
Canada	ICNIRP 1998	Nerve and Muscle Stimulation	833	5,000
USA	ACGHI 1998	Nerve and Muscle Stimulation	1,000	25,000
Germany	DIN/VDE	Nerve and Muscle Stimulation	50,000	20,000
Sweden	MRP	Biological / Precautionary	3	25
Sweden	TCO	Biological / Precautionary	2	10
Switzerland		Biological / Precautionary	10	
WHO "possibly carcinogenic"		Biological / Precautionary	3-4	
Bio-Initiative Report recommendation	Bio-Initiative Report 2007	Biological / Precautionary	1	
US Congress	Recommendation 1996	Biological / Precautionary	2	10
Building Biology Guidelines Germany (Sleeping Areas)	SBM2008 - Level of No Biological Concern	Biological / Precautionary	0.2	0.3
Natural Radiation	MAES 2008	Natural Exposure	0.0002	0.0001
Average Indoor Urban Exposure Toronto, Canada	Safe Living Technologies Inc. 2011		0.4 to 2.0	5 to 25

# EMR Safety Guidelines

## Building Biology Testing Standard (SBM 2008) for Bedrooms

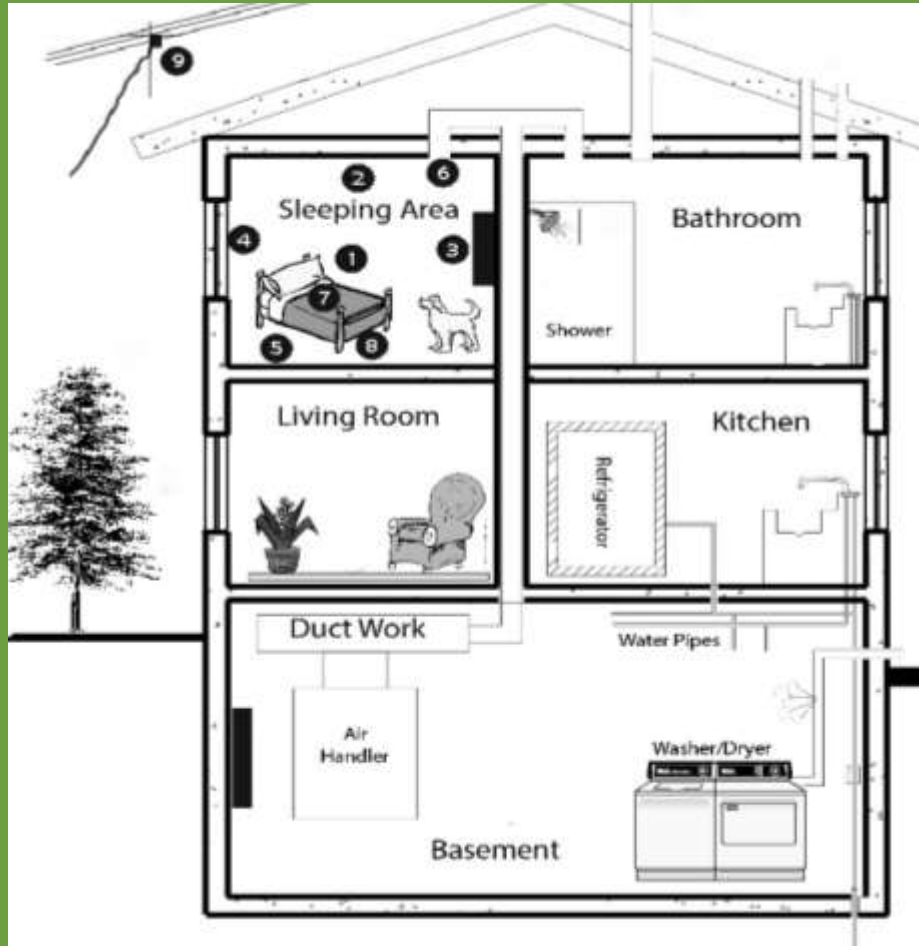
Field, Waves, Radiation	No Concern	Slight Concern	Severe Concern	Extreme Concern
<b>AC ELECTRIC FIELDS</b> (Low Frequency, ELF/VLF)				
<b>Field strength</b> with ground potential in volt per meter (V/m)	< 1	1 - 5	5 - 50	> 50
<b>Body voltage</b> with ground potential in millivolt (mV)	<10	10 - 100	100 - 1000	> 1000
<b>Field strength</b> potential-free in volt per meter (V/m)	<0.3	0.3 - 1.5	1.5 - 1.0	> 10
<b>AC MAGNETIC FIELDS</b> (Low Frequency, ELF/VLF)				
<b>Flux density</b> in nanotesla (nT)	< 20	20 - 100	100 - 500	> 500
<b>Flux density</b> in milligauss (mG)	< 0.2	0.2 - 1.0	1 - 5	> 5
<b>RADIOFREQUENCY RADIATION</b> (High Frequency, Electromagnetic Waves)				
<b>Power density</b> in microwatt per square meter ( $\mu\text{W}/\text{m}^2$ )	< 0.1	0.1 - 10	10 - 1000	> 1000



- Bodies most vulnerable to EMR at night when trying to recover and recuperate
- Building Biology introduced first guidelines for sleeping areas to ensure long-term health

# AC Electric Fields

Possible sources of AC electrical fields (sleeping area):



Electric fields are a result of *voltage*; no current flow is required

1. Bedside lamp, radio, etc.
2. Overhead lighting
3. Circuit panel
4. Wiring in the walls
5. Wiring in the flooring
6. Wiring in the ceiling
7. Electric blanket
8. Extension cords

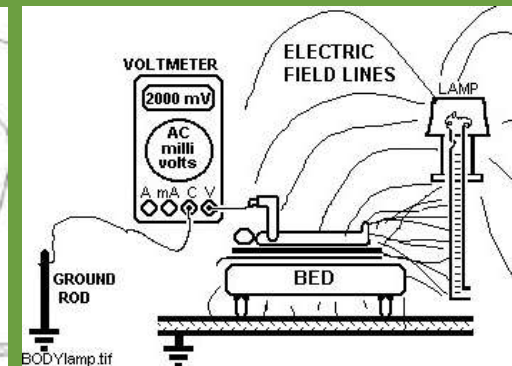
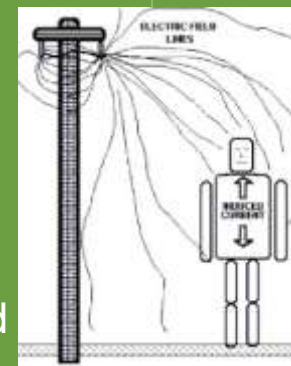
Exterior sources

9. Power distribution lines

- Alternating Field measured in Voltmeter (V/m)
- Body voltage measured in millivolt (mV)
- Electric field lines have a beginning and end = easily shielded by grounded and conductive materials
- Our bodies act as antenna for AC EF

Mitigation options to achieve the lowest body voltage:

- remove source
- keep sufficient distance - 2 metres
- turn off electrical circuit, install shielded cables or add grounding connections



# AC Magnetic Fields

Possible sources of AC magnetic fields (sleeping area):



Magnetic fields occur whenever current is drawn:

1. Bedside lamp, radio, etc.
2. Overhead fluorescent lighting
3. Circuit panel
4. Wiring in the walls
5. Wiring in the flooring
6. Wiring in the ceiling
7. Electric blanket
8. TVs, stereos, refrigerators, etc. (in this room or adjacent room)

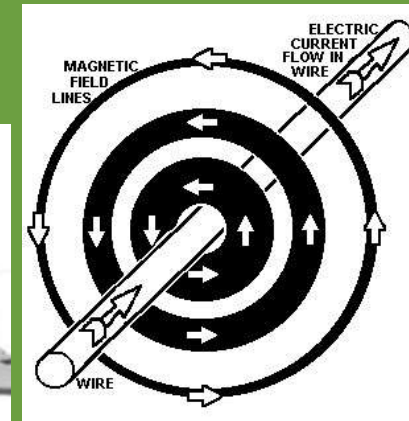
Exterior sources

9. Power transformers

- AC magnetic field strength expressed as ampere per meter (A/m)
- Magnetic flux density in Tesla (T) or Gauss (G)
- Measured with Gaussmeters

Magnetic field hard to shield because they permeate most materials:

- Unplug source device / appliances
- Keep your distance at least 2m
- Stay at least 1m per kV from external distribution transformers & transmission lines
- Fix building wiring errors or de-energize problem circuits while sleeping





# High Frequency Fields

Radio Frequency (RF) radiation can be absorbed by the body

- Microwave radiation is capable of exciting rotation or vibration in heavily polarized water molecules (the body is 70% water). Exciting radiation to heat.
- Sensitive hydrogen bonds in cells and membranes are also affected

Biological effects:

1. Thermal effects – caused by heating
2. Non thermal effects – mediated by the modulation type

Modulation of the frequency is relatively harmless

Modulation of the amplitude is more critical

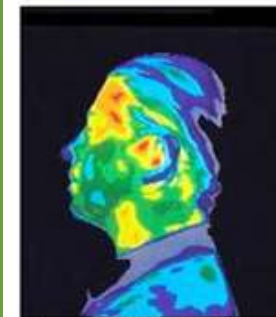
The ELF (Extreme Low Frequency) pulse is the most critical:

- Low-level pulse from a cellular phone base station or wifi network seems to have a bigger impact than a strong signal from an FM radio station

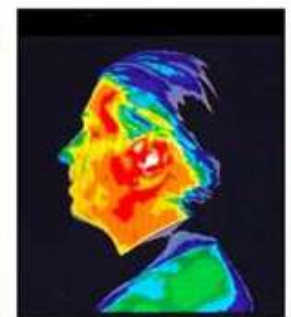
The higher the frequency of EMR the more the electric and magnetic field components meld together

Since the 1950s data points towards a correlation between RF and:

- Leukaemia
- Brain tumours
- Cancer
- Stress symptoms
- Tendency of bleeding and cell dysfunction
- Birth defects
- Behaviours abnormalities



*Thermographic Image of the head with no exposure to harmful cell phone radiation.*



*Thermographic Image of the head after a 15-minute phone call. Yellow and red areas indicate thermal (heating) effects that can cause negative health effects.*

# High Frequency Fields

Possible sources of Radio Frequency (RF) fields:



1. Portable and mobile phones
2. Overhead fluorescent lighting
3. “Smart” utility meters
4. Wireless security systems
5. Wireless internets
6. Microwaves
7. Dimmers
8. RF Baby monitors

Exterior sources

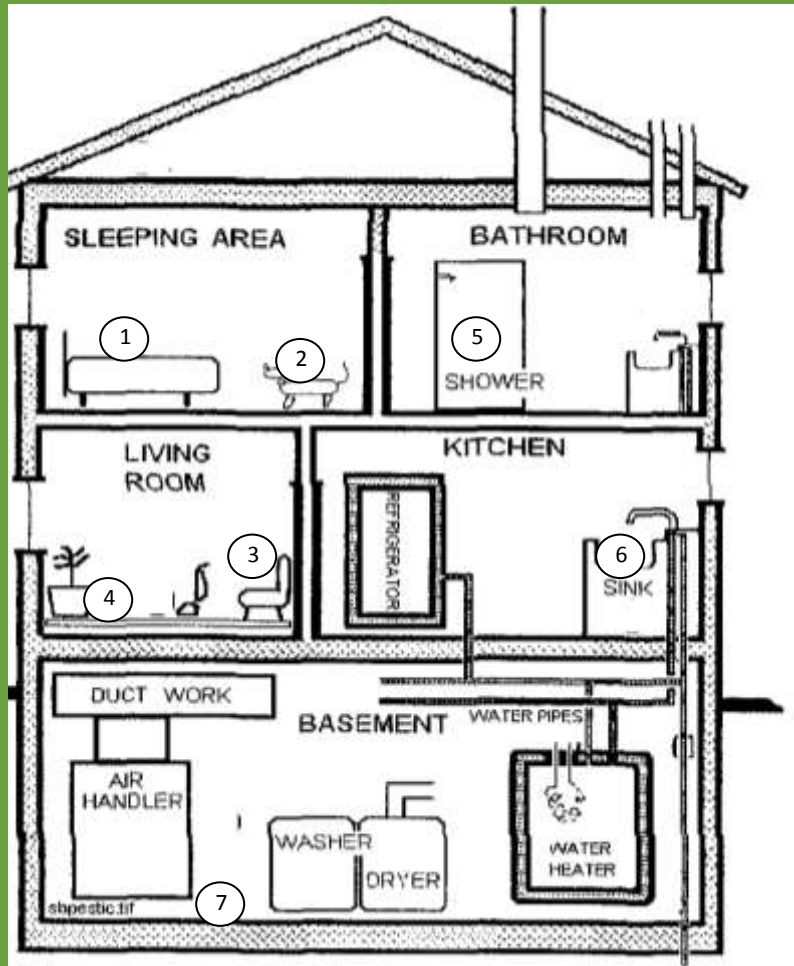
9. Nearby cell towers

- remove potential source & move your bed to an undisturbed zone
- avoid using cell phones if used stay outside and +1m from children
- stay away from cordless phones, wireless devices, RF baby monitors and microwaves
- keep away from radio station and cell towers (not in visible distance of bedroom window)
- external keyboards with laptops, avoid close exposure, earth laptops
- shield a room - windows are the weakest spot

- Radio Frequency radiation (RF) 30 kHz to microwaves 300 kHz
- The unit of power density is watt per m<sup>2</sup> (W/M2).
- Radio frequency radiation or electromagnetic waves are detected with antennas or RF scanners
- World Health Organisation (WHO) study released June 2011 states cell phones are ‘possibly carcinogenic to humans’ – 40% increase risk for a cancer called gliomas amongst heavy cell phone users (30 mins a day over 10 years)

# Electrical Direct Fields

Possible sources of static charge:



Balanced atmospheric electricity is essential to the proper functioning of cell respiration and metabolism

Positive air ions tend to be less beneficial than negative ions which can stimulate the bodies defence system to stay healthy

1. Bedding (synthetic materials)
2. Animals
3. Upholstery
4. Carpet
5. Shower curtain
6. Sinks
7. Vinyl floor
8. TV and computer screens
9. Finishes and certain paints

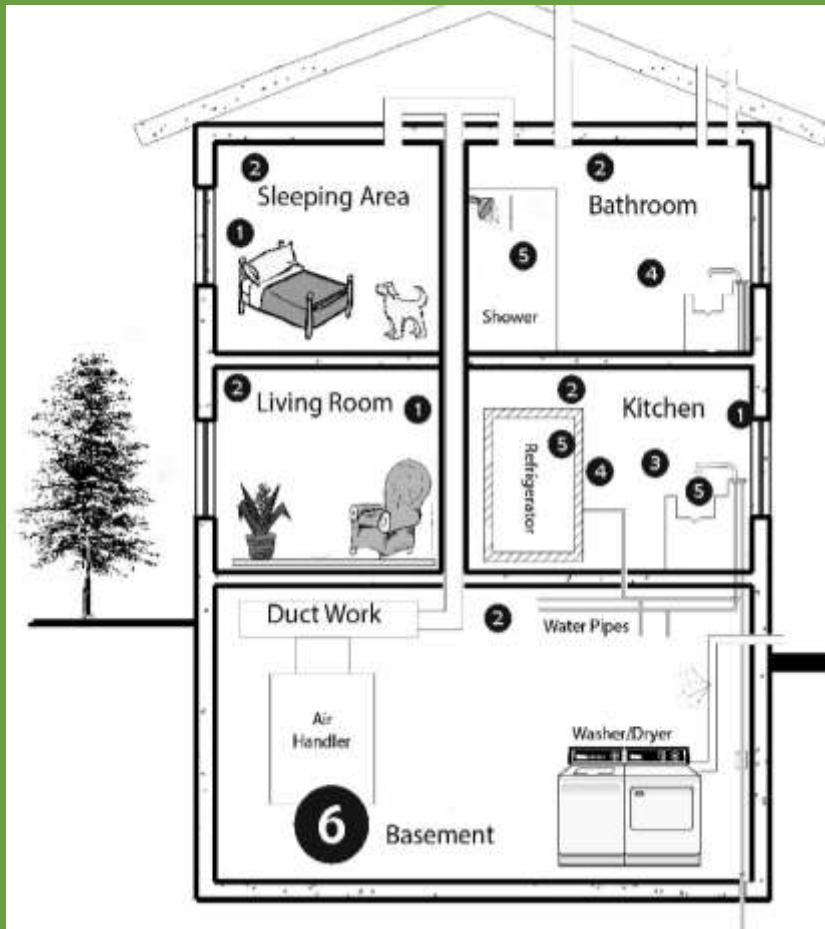
- The voltage of electrostatically charged surfaces is expressed in volt (V)
- The resulting field strength or intensity of such a field, also referred to as air electricity, is given as volt per meter (V/m)
- Natural air electricity usually registers with about 100 to 200 V/m, fluctuating according to diurnal and annual rhythms

Mitigation:

- Use natural or mineral materials
- Use LCD screens
- Use natural oils and waxes to bleed off charges of prefinished laminate
- Untreated or oiled solid wood or cork flooring

# Radioactivity

Possible sources of radioactivity:



1. Clocks and watches
2. Smoke detectors
3. Granite countertops
4. Ceramic glazes and enamels
5. In food & water
6. Radon – radioactive soil gas
7. Certain types of clay

Measured in  $\mu\text{Sv/h}$  = micro Sievert per hour



## MITIGATION OPTIONS

- All radiation exposures should be As Low As Reasonably Attainable (ALARA principle)
- Any dose of radioactivity can cause damage, so remove radioactive material from the area

# Light – Natural EMR

Light is unique in that the amounts, quality and time of the light exposure greatly affect the well-being of living beings

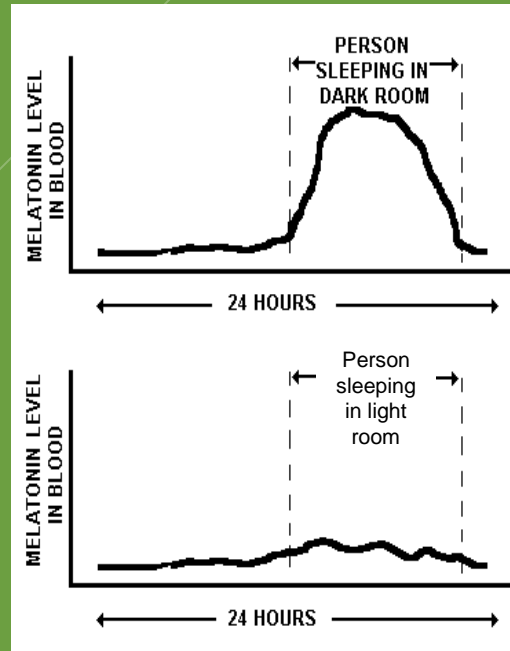
## *Natural Melatonin Circadian Rhythm*

Melatonin provides a mechanism that addresses both chemical and electromagnetic issues

## *Disrupted Rhythm from Light or EMF Switching Exposure.*

Examples of Melatonin functions:

- Day/Night (circadian) cycle
- Free radical scavenging, thus fighting cancer
- Balance of regular sleep patterns - Rapid Eye Movement (REM)



Light can be considered as a nutrient, rather like food;

- the wrong kind can make us ill
- the right kind can keep us healthy

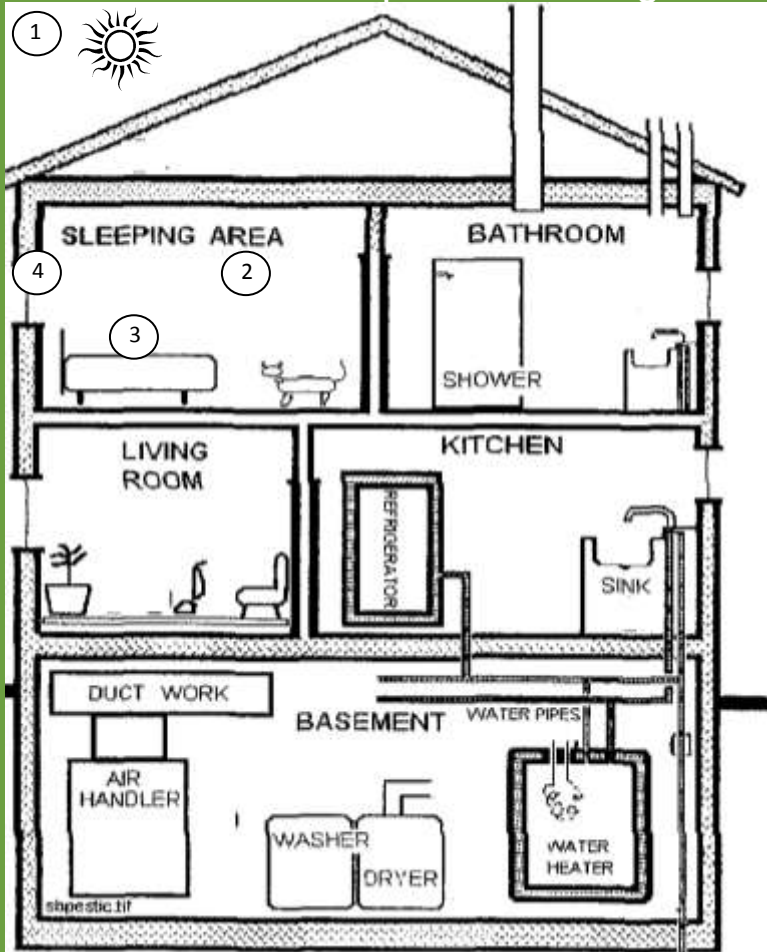
John Ott: *Health and Light*

Visible light because of its wavelength acts mostly like a beam

It is one of the only parts of the EMR spectrum we are consciously aware – the eye

# Light – Natural EMR

Possible sources or problems of light:



1. Sun – natural UV
2. Overhead fluorescent lights
3. Bedside lamps
4. Glass

Lack of natural light can cause:

- Weakened Muscles
- Headache
- Chronic Irritability
- Metabolic Disorders
- Decreased red blood cells
- Fatigue
- Low Blood Pressure
- Depression (SAD)
- Decreased Immune Function
- Female fertility problems
- Hyperactivity

Remedial measures:

- Access to natural light & natural colour rendering
- Minimal use of fluorescent lighting
- At night the room should be electro-magnetically quiet ie: no visible and no electromagnetic fields or frequencies
- Light dimmers, computers and other electronic devices can have complex fields – replace or shield

# Oak Meadow - 35 houses, North Devon



## Air quality

- low VOC
- natural ventilation with solar pre-heating
- reduced dust mite habitat
- non biocides, radon barrier

## Matter

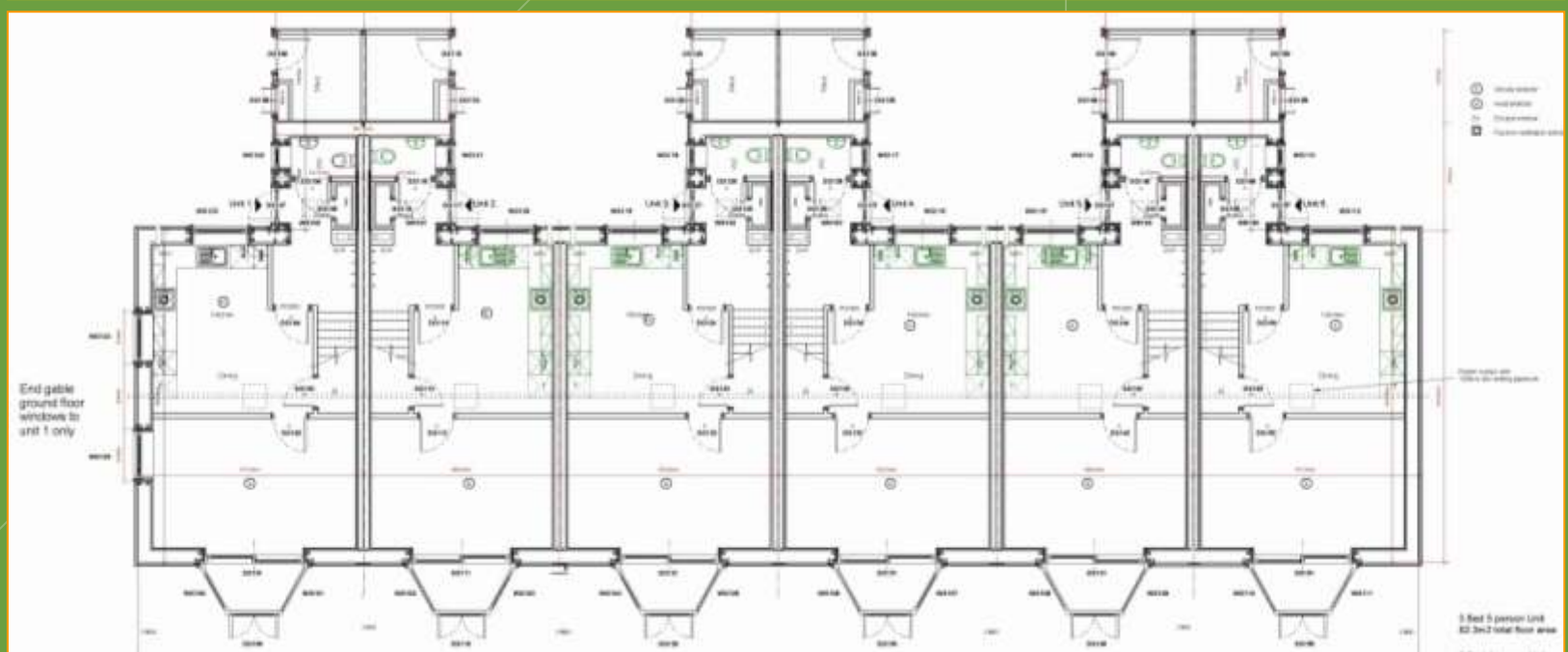
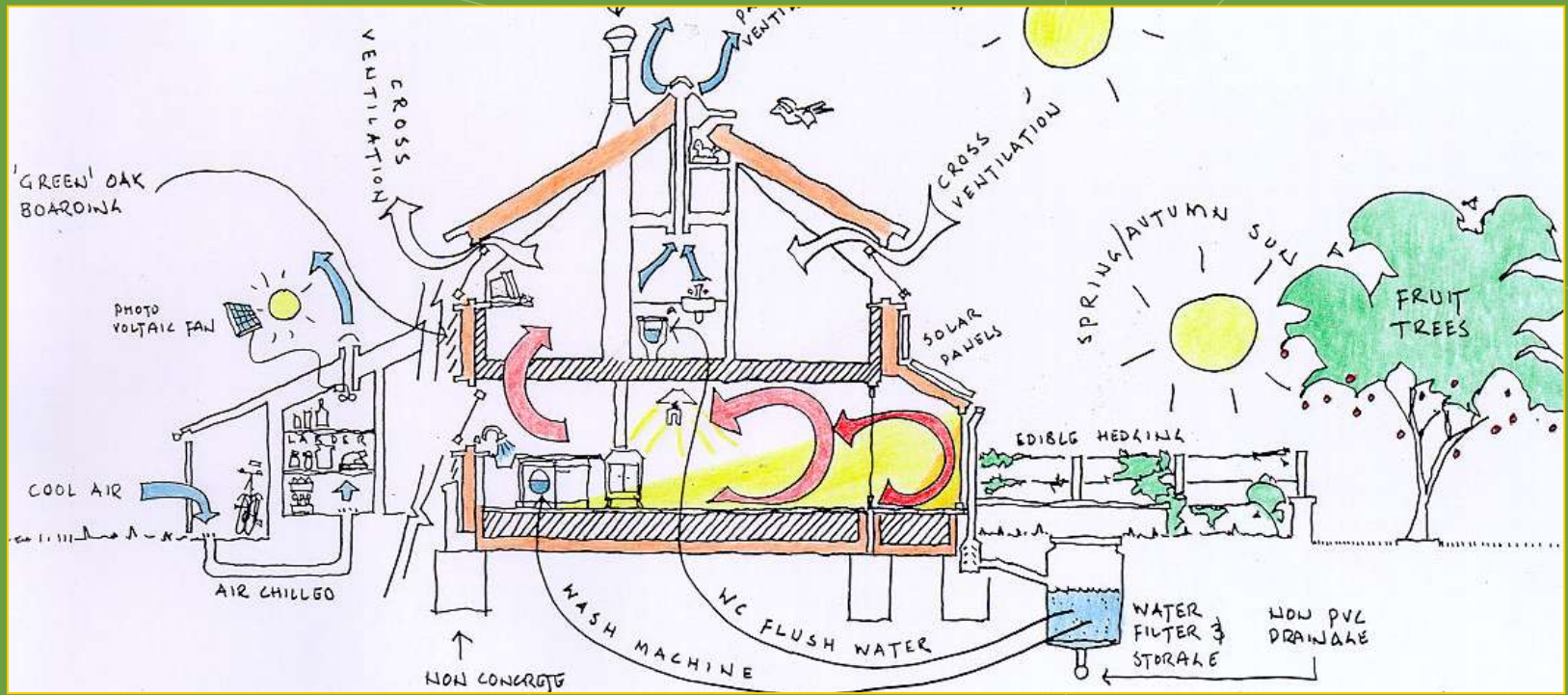
- low embodied energy
- natural, vapour permeable
- minimise PVC

**Water** - rainwater collection & low water use

## Energy

- low energy passive design
- solar thermal & PV, cool larders
- natural daylight design
- radial wiring with shut off circuits in bedrooms













# Duchy Square

New arts centre studios and gallery, Dartmoor



## Air quality

- low VOC
- natural ventilation
- reduced dust mite habitat
- non biocides
- radon barrier

## Matter

- minimise PVC

**Water** - low water use

## Energy

- low energy passive design
- natural daylight design





# Brook Green Centre for Learning

New build special needs school, Plymouth



## Air quality

- low VOC
- natural ventilation
- reduced dust mite habitat
- non biocides
- radon barrier

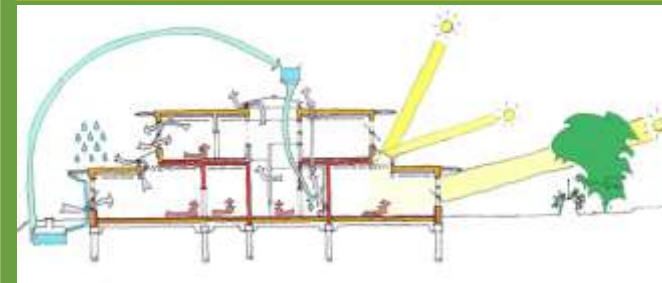
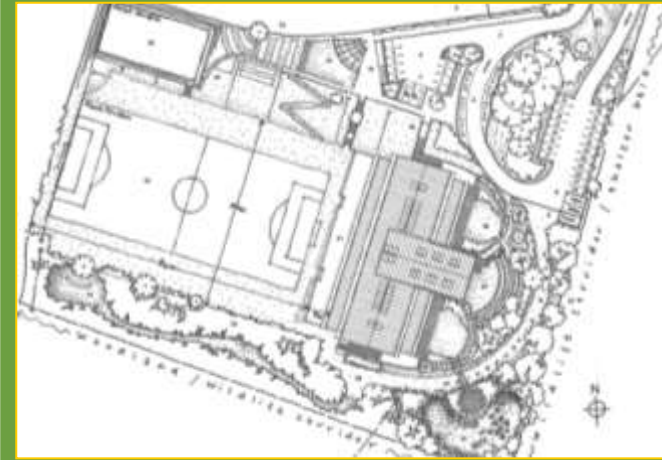
## Matter

- low embodied energy
- natural, vapour permeable
- non PVC

## Water - low water use

## Energy

- low energy passive design
- solar thermal, PV, ground source
- natural daylight design



# The 25 Building Biology Principles

1. Site buildings on geologically undisturbed land.
2. Residential homes are best located away from industrial centers and main traffic routes.
3. Housing shall be developed in a decentralized and loose manner interlaced with sufficient green space.
4. Housing and developments shall be personalized, in harmony with nature, fit for human habitation and family oriented.
5. Use natural and unadulterated building materials.
6. Use wall, floor, and ceiling materials that allow air diffusion and are hygroscopic.
7. Indoor air humidity shall be regulated naturally.
8. Filter and neutralize air pollutants.
9. An appropriate balance of thermal insulation and heat retention is needed.
10. The air and surface temperatures of a given room need to be optimized.
11. Use radiant heat and as much passive solar heat as possible for the heating system.
12. The total moisture content of a new building shall be low and dry out quickly.
13. A building shall have a pleasant or neutral smell.
14. Light, lighting, and color shall be in harmony with natural conditions.
15. Protective measures against noise pollution as well as infrasonic and ultrasonic vibrations need to be human oriented.
16. Use building materials with little or preferably no radioactivity.
17. Maintain the natural balance of atmospheric electricity and ion concentration.
18. The Earth's natural magnetic field shall not be altered or distorted.
19. Eliminate or reduce man-made electromagnetic radiation (EMR) as much as possible.
20. Cosmic and terrestrial radiation is essential and shall be interfered with as little as possible.
21. Interior and furniture design shall be based upon physiological findings.
22. Harmonic measures, proportions, and shapes need to be taken into consideration.
23. Produce, install, and dispose of building materials in a way that does not contribute to environmental pollution and high energy costs.
24. Building activities shall not contribute to the exploitation of non-renewable and rare resources.
25. Building activities shall not cause a rise in social and medical costs.

These principles can be used while planning the construction of a healthy and ecologically friendly home, or while remodeling an existing one

## Goals:

- Ensure life enhancing for inhabitants
- Not detrimental to builders
- As little disruption to the environment as possible



# Knights Place – 21 flats, Exeter City Council



## Air quality

- low VOC
- reduced dust mite habitat
- non biocides
- radon barrier

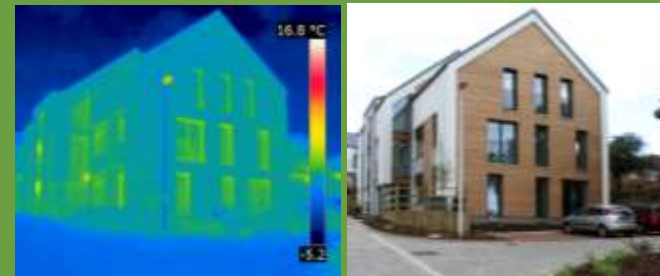
## Matter

- vapour permeable
- hygroscopic building fabric
- non PVC

## Water – low water use

## Energy

- Passivhaus Certified – 21 flats
- natural daylight design
- solar thermal
- radial wiring & reduced wiring





# Westcott House

Passivhaus EnerPHit refurbishment & extension,  
Dartmoor



## Air quality

- low VOC
- MVHR
- reduced dust mite habitat
- non biocides
- radon barrier

## Matter

- low embodied energy
- natural, vapour permeable
- minimise PVC

**Water** – well water & low water use, water filtration

## Energy

- Passivhaus EnerPHit
- solar PV, wood burning
- natural daylight design
- radial wiring



# Sentinel Haus Institute

Independent Institute for healthy construction and housing



## Verification

- site inspection
- on site testing for:

- Air tightness <math><1.0 \text{ h}^{-1}</math>
- Formaldehyde <math><60 \mu\text{g}/\text{m}^3</math>
- VOC <math><1000 \mu\text{g}/\text{m}^3</math>
- Micro dust particles <math><25 \mu\text{g}/\text{m}^3</math>
- Mould same as outside air
- CO<sub>2</sub> <math><1000 \text{ ppm}</math> in use
- MVHR CO<sub>2</sub> controlled
- Radon <math><100 \text{ Bq}/\text{m}^3</math>
- Reduction of EMR by implementing Building Biology good practice guidance

- Health Passport – Certification

Setting Healthy Building standards based on Building Biology

## Training

- designers
- building contractors
- tradesmen

## Mission

*'We stand for quality of life by creating healthy **and** comfortable interior space. Checkable. Ensuring legal compliance. Affordable. For this we create and establish the required know-how and standards. Nationally and internationally'*

Marketing support for healthy homes

# Bio-Centric housing



**Form Factor**

The proposed 354p house type was assessed in the PHPP to evaluate the impact from a compact building form on the space heating demand, primary energy demand and performance requirements for fabric elements (here expressed as wall U value). (The fabric design was based on the COB 1 specification)

A terrace of 7 354p houses appear to be an optimum arrangement, adding further units has a minimal effect.

**GALE SNOWDEN**  
Architectural & Environmental  
Energy Modelling  
www.galesnowden.co.uk

**Space Heating Demand (kWh/m<sup>2</sup>/yr) for n numbers of terraced houses**

n	1	2	3	4	5	6	7
Space Heating Demand (kWh/m <sup>2</sup> /yr)	~20	~15	~13	~12	~11	~10	~9

**Primary Energy Demand (kWh/m<sup>2</sup>/yr) for n numbers of terraced houses**

n	1	2	3	4	5	6	7
Primary Energy Demand (kWh/m <sup>2</sup> /yr)	~140	~125	~115	~110	~105	~100	~95

**Required Wall Uvalue to Meet a Space Heating Demand of 15 kWh/m<sup>2</sup>/yr**

n	1	2	3	4	5	6	7
Required Wall Uvalue	~0.05	~0.08	~0.10	~0.11	~0.12	~0.13	~0.14

**Orientation**

A terrace of 7 354p houses was assessed in the PHPP to evaluate the impact from orientation on the space heating demand, the primary energy demand and on overheating.

**Space Heating Demand (kWh/m<sup>2</sup>/yr) Depending on Orientation**

**Primary Energy Demand (kWh/m<sup>2</sup>/yr) Depending on Orientation**

**Overheating (h per 20°C) Depending on Orientation**

**PHPP Results**

Orientation	Space Heating Demand (kWh/m <sup>2</sup> /yr)	Primary Energy Demand (kWh/m <sup>2</sup> /yr)	Overheating (h per 20°C)
S	~10	~95	~0
SE	~12	~105	~0
E	~15	~115	~10
W	~18	~125	~20
SW	~20	~135	~30
N	~25	~150	~40

- **Building Biology** – meeting Bau Biologie, health homes standards
- **Permaculture** – incorporating Permaculture design principles
- **Passivhaus Certified** – employing sound building physics
- **Life time homes** – adaptable homes to meet future needs
- **Future climate ready** – thermally modeled to meet future predicted weather 2080

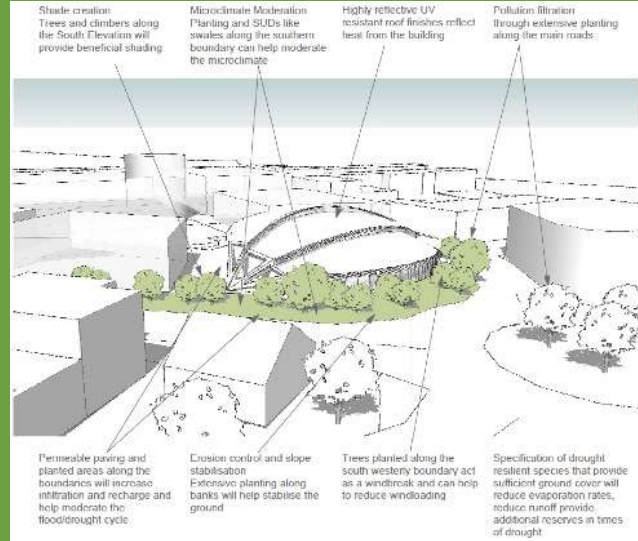
**Low cost** – 1,200/m<sup>2</sup>, equivalent to standard affordable housing

**Affordable to run** – 80% less to run and maintain

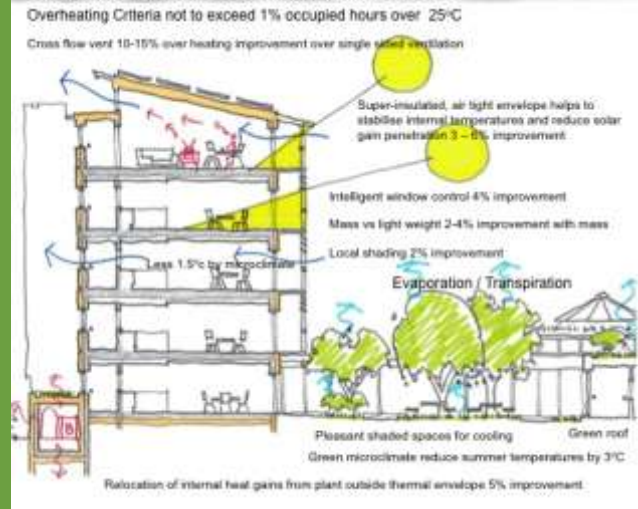


# Future Climate Ready

## Swim4Exeter



## Devonshire Gate Passivoffice

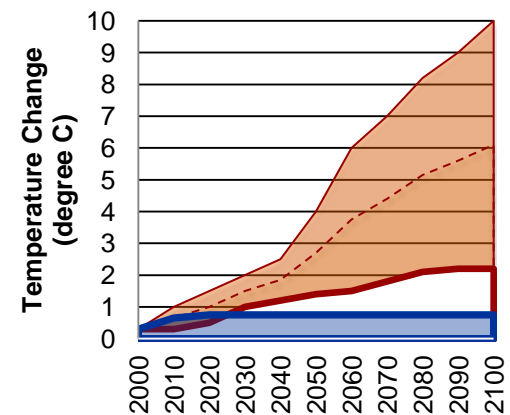


## Extra Care 4 Exeter

## Technology Strategy Board

Building Biology, Passivhaus, Permaculture, Future Climate Ready

- Climate is changing
- 15,000 deaths in France in 2003 heat-wave
- Predicted 4-6 degrees temp increase over next 80 years
- Increased weather events and flooding
- Buildings currently design to 2002 weather
- Buildings need address future weather
- Project cost savings



# Testing equipment

## Air quality / matter

- VOC
- Lead

## Water quality

- Water test kit

## Energy

- Low frequency electromagnetic fields
- High frequency electromagnetic fields
- Infra-red camera
- Radon
- Radioactivity – Geiger Counter
- Daylight – Lux meter



# Acknowledgments

Many thanks to The International Institute of Bau-Biologie & Ecology USA – information taken from the IBE101 course and other materials

## Building Biology Courses

- The International Institute for Bau-Biologie & Ecology IBE 101: Natural Healthy Buildings course (English speaking):

[www.hbelc.org](http://www.hbelc.org)

- Bau Biologie Germany (German speaking):

[www.baubiologie.de](http://www.baubiologie.de)

- UK Building Biology:

[info@ecodesign.co.uk](mailto:info@ecodesign.co.uk)



# Make informed choices

“We shape our buildings, and afterwards our buildings shape us.” (Winston Churchill)

**How is your building shaping you?**

**Protecting or harming?**

You can choose to make it better

# Thank You

For more information on Building Biology:  
[david@ecodesign.co.uk](mailto:david@ecodesign.co.uk)

