In [1]:
```python
from scipy.constants import pi, proton_mass


def num_cells():
    diameter = 10e-6  # m
    cell_vol = 4 / 3 * pi * (diameter / 2) ** 3
    cell_share = 0.5
    bodyweight = 100  # kg
    water_density = 997  # kg / m^3
    body_vol = bodyweight / water_density
    body_cell_vol = body_vol * cell_share
    num_cells = body_cell_vol / cell_vol
    return num_cells


def DNA_length(num_cells):
    base_pairs_per_cell = 6e9  # base pairs per cell
    base_pair_length = 0.34e-9  # m
    return num_cells * base_pairs_per_cell * base_pair_length


def exponential_cells_after(day0_cells, num_days):
    return day0_cells * 2 ** (num_days * 2)


def water_molecules_in_cell():
    density_of_water = 1000  # kg / m^3
    water_share = 0.7
    cell_diameter = 10e-6  # m
    cell_vol = 4 / 3 * pi * (cell_diameter / 2) ** 3
    water_vol = cell_vol * water_share
    water_mass = water_vol * density_of_water
    weigth_of_water_molecule = 18 * proton_mass
    num_water_molecule = water_mass / weigth_of_water_molecule
    return num_water_molecule


if __name__ == "__main__":
    # task 1
    cellnum = num_cells()
    print(f"Number of cells in a Human: {cellnum:.2E}")
    dna_length = DNA_length(cellnum)
    print(f"Total length of DNA in a human: {dna_length:.2E}")

    # task 2
    cells_after_7 = exponential_cells_after(1e6, 7)
    print(f"After 7 days we have {cells_after_7:.2E} cells")

    # task 3
    water_count = water_molecules_in_cell()
    print(f"The amount of water in a cell is {water_count:.2E} water molecules")
```

```
Number of cells in a Human: 9.58E+13
Total length of DNA in a human: 6.51E+08
After 7 days we have 1.00E+98 cells
The amount of water in a cell is 1.22E+13 water molecules
```

Phase contrast microscopy

Constructive vs destructive interference

The criteria for constructive interference is to have waves in the same phase.
The criteria for destructive interference is to have waves out of phase. For greatest effect they need to be $\lambda/2$ apart.

Phase contrast - how it works

To obtain constructive and destructive interference in the phase microscope we use a phase shifting lens. The lens phase shifts the light waves either forwards or backwards by $\lambda/4$. Only the light sent through a specific path that doesnt *scatter* or *diffract* goes through the phase shifting lens.

The light that gets *scattered* or *diffracted* does not go through the phase shifting lens, but is phase shifted (always delayed) by $\lambda/4$. The sum of these two phase shifts are either $\lambda/4 + \lambda/4 = \lambda/2$ which gives destructive interference or $\lambda/4 - \lambda/4 = 0$ which gives constructive interference.

Maximal lateral resolution

In order to get maximum lateral resolution the objective needs to:

- Have a large numerical aperture
- Have a large angle θ to get $\sin\theta$ as close as possible to 1.

Since

$$lateral\ resolution = \frac{0.61\lambda}{n\sin\theta}$$

we need a small wavelength to get the greatest resolution. Blue light has a small wavelength. Electrons have smaller.