

## 2.1 Fluid Compartments

The 70 kg 'standard male' contains 42 liters of water - 60% of his body weight. The hypothetical adult female contains 55% of her body weight as water: this lower percent being due to a higher fat content. These figures are standard values which are quoted frequently and are average values.

### 2.1.1 Variations in Water Content

#### Variation due to Age

Neonates contain more water than adults: 75-80% water with proportionately more extracellular fluid (ECF) than adults. At birth, the amount of interstitial fluid is proportionally three times larger than in an adult. By the age of 12 months, this has decreased to 60% which is the adult value.

Total body water as a percentage of total body weight decreases progressively with increasing age. By the age of 60 years, total body water (TBW) has decreased to only 50% of total body weight in males mostly due to an increase in adipose tissue.

#### Variation between Tissues

Most tissues are water-rich and contain 70-80% water. The three major exceptions to this are:

#### Variation between Individuals

The variation between individuals in the ratio of TBW to total body weight is quite large but the majority of the variation is due to different amounts of adipose tissue. Obese adults have a lower ratio. For any particular tissue of the body the variation is much less but any variation that occurs is still mostly due to differences in amount of adipose tissue.

- Plasma: 93% water (& 7% 'plasma solids')
- Fat: 10-15% water
- Bone: 20% water

### 2.1.2 Compartments

The water in the body is contained within the numerous organs and tissues of the body. These innumerable fluids can be lumped together into larger collections which can be discussed in a physiologically meaningful way. These collections are referred to as compartments. The major division is into Intracellular Fluid (ICF: about 23 liters) and Extracellular Fluid (ECF: about 19 liters) based on which side of the cell membrane the fluid lies. Typical values for the size of the fluid compartments are listed in the table.

<b>Body Fluid Compartments (70 kg male)</b>			
	<b>% of Body Weight</b>	<b>% of Total Body Water</b>	<b>Volume (Litres)</b>
<b>ECF</b>	<b>27</b>	<b>45</b>	<b>19</b>
Plasma	4.5	7.5	3.2

ISF	12.0	20.0	8.4
Dense CT water	4.5	7.5	3.2
Bone water	4.5	7.5	3.2
Transcellular	1.5	2.5	1.0
<b>ICF</b>	<b>33</b>	<b>55</b>	<b>23</b>
<b>TBW</b>	<b>60%</b>	<b>100%</b>	<b>42 liters</b>

### 2.1.3 Intracellular Fluid

The Intracellular Fluid is composed of at least  $10^{14}$  separate tiny cellular packages. The concept of a single united "compartment" called intracellular fluid is clearly artificial. The ICF compartment is really a "virtual compartment" considered as the sum of this huge number of discontinuous small collections. How can the term 'intracellular fluid' be used as though it was a single body of fluid? The reason is that though not united physically, the collections have extremely important unifying similarities which make the ICF concept of practical usefulness in physiology. In particular, similarities of location, composition and behaviour:

- Location: The distinction between ICF and ECF is clear and is easy to understand: they are separated by the cell membranes
- Composition: Intracellular fluids are high in potassium and magnesium and low in sodium and chloride ions
- Behaviour: Intracellular fluids behave similarly to tonicity changes in the ECF

Because of this physiological usefulness, it is convenient to talk of an idealised ICF as though it were a single real entity. The use of this convention allows predictions to be made about what will happen with various interventions and within limits these are physiologically meaningful.

### 2.1.4 Extracellular Fluid

A similar argument applies to the Extracellular Fluid. The ECF is divided into several smaller compartments (eg plasma, Interstitial fluid, fluid of bone and dense connective tissue and transcellular fluid). These compartments are distinguished by different locations and different kinetic characteristics. The ECF compositional similarity is in some ways, the opposite of that for the ICF (ie low in potassium & magnesium and high in sodium and chloride).

**Interstitial fluid (ISF)** consists of all the bits of fluid which lie in the interstices of all body tissues. This is also a 'virtual' fluid (ie it exists in many separate small bits but is spoken about as though it was a pool of fluid of uniform composition in the one location). The ISF bathes all the cells in the body and is the link between the ICF and the intravascular compartment. Oxygen, nutrients, wastes and chemical messengers all pass through the ISF. ISF has the compositional characteristics of ECF (as mentioned above) but in addition it is distinguished by its usually low protein concentration (in comparison to plasma). Lymph is considered as a part of the ISF. The lymphatic system returns protein and excess ISF to the circulation. Lymph is more easily obtained for analysis than other parts of the ISF.

**Plasma** is the only major fluid compartment that exists as a real fluid collection all in one location. It differs from ISF in its much higher protein content and its high bulk flow (transport function). Blood contains suspended red and white cells so plasma has been called the 'interstitial fluid of the blood'. The fluid compartment called the blood volume is interesting in that it is a composite compartment containing ECF (plasma) and ICF (red cell water).

**The fluid of bone & dense connective tissue** is significant because it contains about 15% of the total body water. This fluid is mobilised only very slowly and this lessens its importance when considering the effects of acute fluid interventions.

**Transcellular fluid** is a small compartment that represents all those body fluids which are formed from the transport activities of cells. It is contained within epithelial lined spaces. It includes CSF, GIT fluids, bladder urine, aqueous humour and joint fluid. It is important because of the specialised functions involved. The fluid fluxes involved with GIT fluids can be quite significant. The electrolyte composition of the various transcellular fluids are quite dissimilar and typical values or ranges for some of these fluids are listed in the Table.

The total body water is divided into compartments and useful physiological insight and some measure of clinical predictability can be gained from this approach even though most of these fluid compartments do not exist as discrete real fluid collections.

**2.1.5 Functional ECF**

The water in bone and dense connective tissue and the transcellular fluids is significant in amount but is mobilised much more slowly than the other components of the ECF. The remaining parts of the ECF are called the functional ECF. The ratio of ICF to ECF is 55:45.

The functional ECF is more important when considering the effects of acute fluid interventions and the ratio of ICF to functional ECF is 55:27.5 (which is 2:1). (See Section 8.1 for discussion of acute fluid infusions).

<b>Typical Electrolyte Concentrations in Some Transcellular Fluids (in mmol/l)</b>				
	<b>[Na<sup>+</sup>]</b>	<b>[K<sup>+</sup>]</b>	<b>[Cl<sup>-</sup>]</b>	<b>[HCO<sub>3</sub><sup>-</sup>]</b>
Saliva	20-80	10-20	20-40	20-60
Gastric juice	20-100	5-10	120-160	0
Pancreatic juice	120	5-10	10-60	80-120
Bile	150	5-10	40-80	20-40
Ileal fluid	140	5	105	40
Colonic fluid	140	5	85	60
Sweat	65	8	39	16
CSF	147	3	113	25