Red and White Muscle

Skeletal muscles are highly preserved tissues in animals, are present all over the body, and form a combined network with a notable skeletal system via tendons to resist gravity and facilitate mobility. There are two major categories of muscle fibers in vertebrates:

1. Red fibers and
2. White fibers.

Red muscle and white muscle are skeletal muscles which perform various functions in the body. Red muscles are named so because they are dense with capillaries and are rich in myoglobin and mitochondria which gives it a characteristic red appearance. On the other hand, white muscles have comparatively less mitochondria and myoglobin, giving the muscles a "whitish" appearance. The dominant work of some muscles is to maintain a standing posture or to contract slowly during locomotion, chewing or breathing. Such muscles tend to contain a high proportion of slow-contracting and fatigue-resistant fibers with a high myoglobin concentration. The capillary bed of red muscles is denser than in white muscles.

Morphological studies showed that red fibers (slow twitch, oxidative fibers) are small in diameter and have a red color, due to their greater content of myoglobin and rich supply of capillaries. They have numerous large mitochondria beneath the sarcolemma and between the myofibrils. Lipid droplets are common in the sarcoplasm of these fibers. In contrast, white fibers (fast-twitch fibers) are larger in diameter. Their mitochondria and lipid droplets are smaller and less numerous than those of red fibers. The properties of red muscle fibers make them very effective in postural maintenance, while white muscle fibers are suited for bursts of intense muscle activity.

In addition to morphological observations, physiologists have reported that red muscle fibers contract more slowly and are more resistant to fatigue than are white muscle fibers due to their ability to oxidatively regenerate ATP. In contrast, ATP generation in white muscle fibers depends on anaerobic glycolysis. It is accepted that hydrolysis of ATP by ATPase is directly involved as the energy supply in the process of muscle contraction. Biochemical studies revealed that the ATPase activity of white muscle fibers is 3 times higher than that of red muscle fibers. However, in a resting state, whether ATP is stored for use in muscle fibers and whether the stored ATP content in red muscle fibers is more or less than that in white muscle fibers are still unclear.

Red muscle has a greater concentration of the pigment myoglobin, is generally lower in soluble protein content, lower in glycogen, and higher in lipid than white muscle. Red fibers are smaller in size than white fibers, are better supplied with capillaries, and contain more mitochondria. White fibers are equipped better for glycolytic metabolism than are red fibers, which are designed for oxidative metabolism. Isolated sarcoplasmic reticulum fragments from white muscle have a greater *in vitro* calcium-binding ability than those from red muscle and the myosin from red muscle has a lower ATPase activity than that from white muscle. The physiological response of red and white fibers corresponds well with what has been stated about their composition and biochemical properties. Stimulation of a white fiber produces a twitch response; a twitch response is also elicited in red fibers, but it gives a slower contraction which covers a longer period of time than that from a white fiber. Histochemical techniques have produced many beautiful and useful pictures of fiber type distribution. Red fibers are high in oxidative enzymes, such as SDH, but low in glycolytic enzymes, such as phosphorylase and also low in ATPase; the opposite situation exists in white fibers. Intermediate fibers are well recognized.

❖ Difference between white muscle and red muscle fibers

		Red Muscle Fibers (Tonic)	White Muscle Fibers (Twitch)
1.	**Definition**	Red muscles are a type of skeletal muscle which are dense with capillaries and is rich in myoglobin and mitochondria	White muscles are also a type of skeletal muscle, but contains lower amounts of myoglobin and mitochondria
2.	**Size**	These are thin and smaller in size.	These are thick and larger in size.
3.	**Colour**	They are red in colour as they contain a large amount	They are white in colour as they contain a small amount

		of myoglobin.	of myoglobin.
4.	**Mitochondria**	They contain numerous mitochondria.	They contain less number of mitochondria.
5.	**Sarcoplasmic Reticulum**	Red muscles have reduced quantities of SR. Sarcoplasmic reticulum is moderately developed.	White muscles have more SR. Sarcoplasmic reticulum is well developed.
6.	**Vascularisation**	The fibres are supplied with abundant blood capillaries.	They are moderately vascularised.
7.	**Lactic acid**	Lactic acid does not accumulate.	Lactic acid accumulates.
8.	**Fatigue**	Can perform aerobic oxidation without accumulating much lactic acid – hence, can contract for long periods of time	Performs anaerobic oxidation and accumulates lactic acid much quicker than red muscles – hence, gets fatigued after short bursts of contraction
9.	**Rate of Contractions**	Slow rate of contraction	Fast rate of contraction
10.	**Work pattern**	They carry out slow and sustained contractions for a long period.	They carry out fast work for a short duration.
11.	**Respiratory pattern**	They perform aerobic respiration.	During strenuous exercise, it switches over to anaerobic respiration.
12.	**Example**	Extensor muscle	Muscles of the eyes

❖ Fast and Slow Fibers

At first sight, historically speaking, it appeared that the relationship between fast and slow fibers in meat animals was quite simple. From the time of Ranvier onwards, it had been known that fast fibers were usually white, while slow fibers were usually red. When redness was found to be due to myoglobin, and myoglobin was found to be correlated with aerobic metabolism, this explained the relationship between redness and speed of contraction. The pale or white fibers with a low aerobic potential were found to be well endowed with glycolytic enzymes that enabled them to obtain energy rapidly by the incomplete oxidation of glycogen. This explained why white fibers soon became fatigued once their glycogen stores were depleted and why they had to wait for the removal of lactate by the circulatory system.