varieties in their cohesion. In some the fibres have no la­teral cohesion, as in the case of a rope. The only way in which all the fibres can be made to unite their strength, is to twist them together. This causes them to bind each other so fast, that any one of them will break before it can be drawn out of the bundle. In other fibrous bodies, such as timber, the fibres are held together by some cement or gluten. This is seldom as strong as the fibre. Accord­ingly timber is much easier pulled asunder in a direction transverse to the fibres. There is, however, every possible variety in this particular.

In stretching and breaking fibrous bodies, the visible ex­tension is frequently very considerable. This is not solely the increasing of the distance of the particles of the coher­ing fibre ; the greatest part chiefly arises from drawing the crooked fibre straight. In this, too, there is great diversi­ty ; and it is accompanied with important differences in their power of withstanding a strain. In some woods, such as fir, the fibres on which the strength most depends are very straight. Such woods are commonly very elastic, do not take a set, and break abruptly when overstrained : others, such as oak and birch, have their resisting fibres very undulating and crooked, and stretch very sensibly by a strain. They are very liable to take a set, and they do not break so suddenly, but give warning by *complaining,* as the carpenters call it ; that is, by giving visible signs of a derangement of texture. Hard bodies of an uniform glassy structure, or granulated like stones, are elastic through the whole extent of their cohesion, and take no set, but break at once when overloaded.

Notwithstanding the immense variety which nature ex­hibits in the structure and cohesion of bodies, there are cer­tain general facts of which we may now avail ourselves with advantage. In particular,

The absolute cohesion is proportional to the area of the section. This must be the case where the texture is per­fectly uniform, as we have reason to think it is in glass and the ductile metals. The cohesion of each particle being alike, the whole cohesion must be proportional to their number, that is, to the area of the section. The same must be admitted with respect to bodies of a granulated texture, where the granulation is regular and uniform. The same must be admitted of fibrous bodies, if we suppose their fibres equally strong, equally dense, and similarly disposed through the whole section ; and this we must either suppose, or must state the diversity, and measure the cohesion accord­ingly.

We may therefore assert, as a general proposition on this subject, that the absolute strength in any part of a body, by which it resists being pulled asunder, or the force which must be employed to tear it asunder *in that part,* is propor­tional to the area of the section perpendicular to the ex­tending force.

Therefore all cylindrical or prismatical rods are equally strong in every part, and will break alike in any part ; and bodies which have unequal sections will always break in the slenderest part. The length of the cylinder or prism has no effect on the strength. Also the absolute strengths of bodies which have similar sections are proportional to the squares of their diameters or homologous sides of the section.

The weight of the body itself may be employed to strain it and to break it. It is evident, that a rope may be so long as to break by its own weight. When the rope is hanging perpendicularly, although it is equally strong in every part, it will break towards the upper end, because the strain on any part is the weight of all that is below it. Its *relative strength* in any part, or power of withstanding the strain which is actually laid on it, is inversely as the quantity be­low that part.

When the rope is stretched horizontally, as in towing a ship, the strain arising from its weight often bears a very sensible proportion to its whole strength.

These are the chief general rules which can be safely deduced from our clearest notions of the cohesion of bodies. In order to make any practical use of them, it is proper to have some measures *of* the cohesion of such bodies as are commonly employed in our mechanics, and other structures where they are exposed to this kind of strain. These must be deduced solely from experiment ; therefore they must be considered as no more than general values, or as the averages of many particular trials. The irregularities are very great, because none of the substances are constant in their texture and firmness. Metals differ by a thousand circumstances unknown to us, according to their purity, to the heat with which they were melted, to the moulds in which they were cast, and the treatment they have afterwards received, by forging, wire-drawing, temper­ing, &c.

It is a very curious and inexplicable fact, that by forging a metal, or by frequently drawing it through a smooth hole in a steel plate, its cohesion is greatly increased. This operation undoubtedly deranges the natural situation of the particles. They are squeezed closer together in one direction, but it is not in the direction in which they resist the fracture. In this direction they arc rather separated to a greater distance. The general density, however, is augmented in all of them except lead, which grows rather rarer by wire-drawing ; but its cohesion may be more than tripled by this operation. Gold, silver, and brass, have their cohesion nearly tripled ; copper and iron have it more than doubled. In this operation they also grow much harder. It is proper to heat them to redness after drawing a little. This is called *nealing* or *annealing.* It softens the metal again, and renders it susceptible of another draw­ing without the risk of cracking in the operation.

We do not pretend to give any explanation of this re- markuble and very important fact, which has something re­sembling it in woods and other fibrous bodies, as will be mentioned afterwards.

The varieties in the cohesion of stones and other minerals, and of vegetable and animal substances, are hardly suscep­tible of any description or classification.

We shall take for the measure of cohesion the number of pounds avoirdupois which are just sufficient to tear asun­der a rod or bundle of one inch square. From this it will be easy to compute the strength corresponding to any other dimension.

1st, *Metals.* lbs.

Gold, cast } 20,000 24, 000

Silver, cast } 40,000, 43,000

Copper, cast, { Japan 19,000

Barbary 22,000

Hungary 31,000

Anglesea. 34,000

Sweden 37,000

Iron, cast } 42,000, 59,000

Iron, bar } Ordinary 68,000

Stirian 75,000

Best Swedish and Russian 84,000

Horse-nails 71,000@@l

@@@1 This was an experiment by Muschenbroeck, to examine the vulgar notion that iron forged from old horse-nails was stronger than all others, and shows its falsity.