The idea that there are five senses goes back at least as far as Aristotle. But it is not quite true.

Four of the senses are obvious, if only because each is associated with a particular organ: sight with the eyes, hearing with the ears, taste with the tongue and smell with the nose.

But the fifth classical sense, touch, is distributed over the whole surface of the body, albeit that it is concentrated in the fingertips.

Touch, moreover, is only one such distributed sense. Others perceived consciously include pain, heat and cold.

And modern science has shown there are also unconsciously perceived senses, known collectively as proprioception. These keep track of the position and movement of the body and its parts.

This year's Nobel prize for physiology or medicine went to the discoverers of the molecular mechanisms of two of these distributed senses—temperature and mechanical stimulation.

The winners were David Julius of the University of California, San Francisco and Ardem Patapoutian of Scripps Research, a biomedical institute in San Diego.

Dr Julius did the pioneering work on temperature. He and Dr Patapoutian, acting independently, then advanced this work. After that, Dr Patapoutian moved on to look at mechanical stimulation.

Dr Julius's chosen tool for his investigation, which he began in the late 1990s, was capsaicin. This is the active ingredient of chilli peppers.

By a chemical coincidence (as was then assumed and is now known) capsaicin reacts with, and thus stimulates, one of the body's heat-receptor proteins.

Dr Julius set out to discover what this protein was. To do so he made millions of fragments of genetic material for proteins known to be active in heat-receptor cells.

He then introduced these fragments into other cells, to encourage them to manufacture the relevant protein fragments. That done, he tested the modified cells for sensitivity to capsaicin.

The fragments which induced capsaicin sensitivity turned out to be parts of a protein now called TRPV1. This belongs to a class of proteins called ion channels, which do many jobs in the body.

As predicted, TRPV1 turned out to be heat sensitive. When the temperature rises above 43°C, the channel through it opens, permitting ions of calcium and sodium to pass.

That chemical signal stimulates a nerve impulse which tells the brain about the temperature change.

TRPV1 turned out to be one of several temperature-sensitive ion channels, some of which register heat, and some cold. It was one of the cold-sensitive varieties, TRPM8, which was discovered simultaneously by Dr Julius and Dr Patapoutian.

Dr Patapoutian then went on to look at the sensation of touch.

Molecular biology having advanced in the interim, he was able to work with whole proteins—or, rather, the genes for whole proteins.

He identified 72 proteins, expressed in a mechanically sensitive cell line, that looked like potential touch-sensitive ion channels.

He tested them one at a time, by silencing the genes that encode them and poking the resulting cells. The first 71 silencings had no effect. But the 72nd proved to be of the protein he was looking for. He called that protein PIEZO1.

In nature, PIEZO1 is found not in sensory neurons, but rather in organs like the bladder where pressure sensitivity is important. But Dr Patapoutian discovered a similar channel, PIEZO2, which is, indeed, found in nerve endings. It is this that is responsible for touch and proprioception.

Fascinating work, then. And important. It is through the senses, and the senses alone, that people are able to perceive the world. But to some the award came as a surprise.

In a year of covid, they had been expecting the honours to go elsewhere—perhaps to the inventors of mRNA-vaccine technology.

Like God, however, the various Nobel-prize committees work in mysterious ways their wonders to perform.

人有五种感官的想法至少可以追溯到亚里士多德。但这样说也并不完全准确。

有四种感官是显而易见的，因为每一种感官都与特定的器官相关：用眼睛看，用耳朵听，用舌头尝，用鼻子闻。

但是第五种经典感觉，触觉，分布在整个身体表面，集中在指尖。

此外，触觉只是一种分布式感觉。其他有意识的感觉还包括疼痛、热和冷。

现代科学表明，还有一些无意识的感知器官，统称为本体感觉。这些器官跟踪身体及各部分的位置和运动。

今年的诺贝尔生理学或医学奖授予了温度和机械刺激这两种分布式感官的分子机制的发现者。

获奖者是加州大学旧金山分校的戴维·朱利叶斯（David Julius）和圣地亚哥斯克里普斯生物医学研究所的阿代姆·帕塔博蒂安（Ardem Patapoutian）。

朱利叶斯博士在温度方面做了开创性的工作。他和帕塔博蒂安博士各自独立地推进了这项工作。 在那之后，帕塔博蒂安博士继续研究机械刺激方面的内容。

朱利叶斯博士 20 世纪 90 年代末开始了他的研究，他选择的工具是辣椒素，是辣椒的一种活性成分。

由于化学上的巧合（当时是假设，现在已经知道了），辣椒素与人体的一种热感受器蛋白发生反应，从而刺激人体。

朱利叶斯博士开始着手研究这种蛋白质是什么。为了做到这一点，他制造了数以百万计的遗传物质片段，用于已知的热感受器细胞中活跃的蛋白质。

然后，他将这些片段引入其他细胞，以刺激它们制造相关的蛋白质片段。完成后，他测试了转基因细胞对辣椒素的敏感性。

引起辣椒素敏感性的片段原来是一种叫做 TRPV1 的蛋白质的一部分。这属于一种叫做离子通道的蛋白质，它在体内有很多作用。

正如预测的那样，TRPV1 是热敏的。当温度上升到 43°C 以上时，通道打开，允许钙离子和钠离子通过。

这种化学信号会刺激神经冲动，从而告诉大脑温度的变化。

TRPV1 是几种对温度敏感的离子通道之一，其中一些记录热量，一些记录寒冷。它是一种对冷敏感的变种，由 TRPM8 变化得来的，这些是由朱利叶斯和帕塔博蒂安博士同时发现的。

帕塔博蒂安博士接着研究了触觉。

在此期间，分子生物学取得了进展，他能够研究全蛋白，或者更确切地说，全蛋白基因。

他鉴定了 72 种蛋白质在机械敏感的细胞系中表达，看起来像潜在的接触敏感离子通道。

他通过沉默编码它们的基因并戳出产生的细胞，一次测试一个。前 71 次沉默没有任何效果。 但第 72 颗被证明是他在寻找的蛋白质。他称这种蛋白质为 PIEZO1 蛋白。

在自然界中，PIEZO1 并不存在于感觉神经元中，而是存在于像膀胱这样的重要器官中。但帕塔博蒂安博士发现了一个类似的通道，PIEZO2，它确实存在于神经末梢。这就是触觉和本体感觉的来源。

有趣的工作和重要的事，通过感官，而且只能通过感官，人们才能感知世界。 但对一些人来说，这个奖项是出乎意料的。

在新冠肺炎爆发的一年，他们一直期待着这个荣誉会落到其他地方——也许会落到 mRNA 疫苗技术的发明者身上。

然而，就像上帝一样，各个诺贝尔奖委员会以神秘的方式创造了他们的奇迹。