

The Nature and Science of **COLOUR**

色彩的奥秘



Jane Burton and Kim Taylor 著 孙建华 译



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色彩的奥秘

Jane Burton and Kim Taylor 著

孙建华 译

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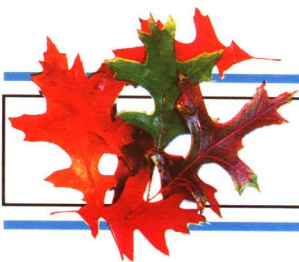
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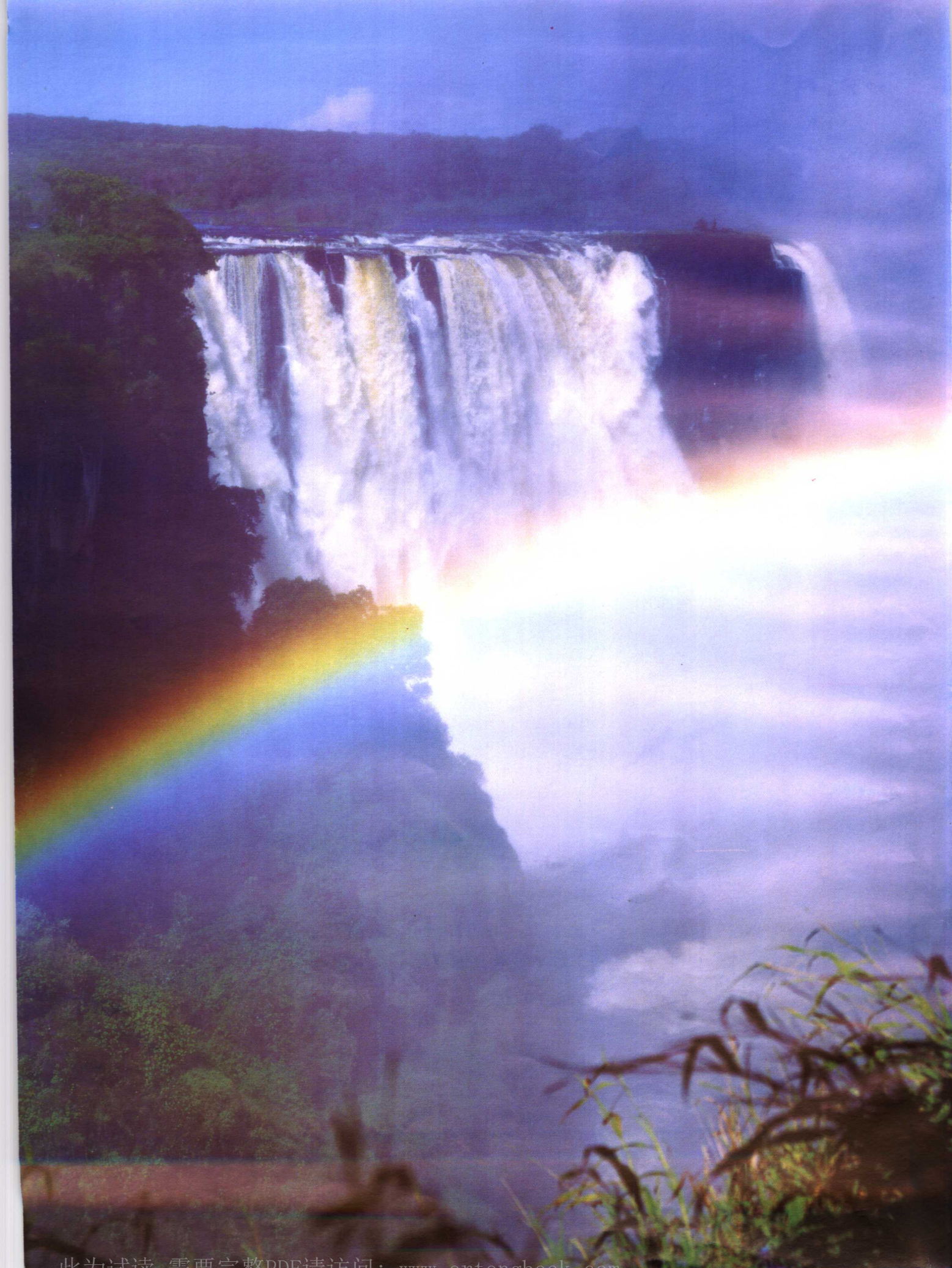
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Seeing Colour 分辨色彩

A rainbow gleams with the purest colours—red, orange, yellow, green, blue, indigo and violet. In fact, these colours merge, one into another. There is a whole range of different shades between these main colours which our very sensitive eyes can see, but for which we do not have names.

The ability to distinguish between minutely different shades of colour is very important to us, as it is to many other animals. Birds, for instance, can pick out a juicy caterpillar because it is a slightly different shade of green from that of the leaf on which it is sitting. Without colour vision, finding food would be much more difficult.

Not all animals can see colours, however. Dogs probably see the world in shades of one colour. Colour is not so important to them because they rely more on another sense which is poorly developed in us. Dogs can smell their way around their world.

彩虹绚丽多姿，呈现出最纯的色彩——红、橙、黄、绿、蓝、青、紫，但实际上，这些色彩之间有相互交融之点，没有明显的分界线。在人敏锐的眼睛所能区分的各种主要色彩之间，还有很多种不同色度的颜色，只是我们叫不出它们的名称。

分辨不同色度细微差别的能力对我们人类极为重要，对其它许多动物也如此。比如，鸟能发现汁多肉嫩的毛虫，这是因为毛虫的绿色与其所爬伏的枝叶的绿色在色度上有轻微的区别。如果丧失这种辨色能力，将会给觅食造成很大的困难。

不过，并不是所有的动物都有辨色的本领。狗看到的世界很有可能是单调的一种色彩。辨色对狗并不很重要，这是因为它们更多地依赖非常灵敏的嗅觉感官，而我们人类的嗅觉却很迟钝。狗靠它的嗅觉就能走遍天下。

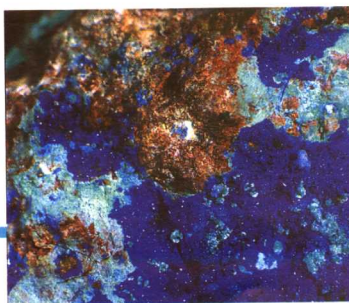
◀ A rainbow spans the spray-filled gorge of Victoria Falls on a sunny afternoon in Zimbabwe.

阳光明媚的午后时光，一道彩虹横跨浪花飞溅的津巴布韦维多利亚瀑布出水口。

Violet 紫



Indigo 青



Red 红



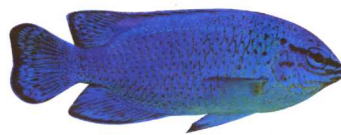
Orange 橙



Yellow 黄



Green 绿



Blue 蓝



The Colours of Light

光的色彩

The wings of some yellow butterflies reflect ultraviolet patterns, invisible to us but conspicuous to other butterflies.

某些粉蝶的翅膀能反射紫外线的波光，人的眼睛根本看不到，但对其它蝴蝶却显而易见。

To understand colour, you must understand the nature of light. Light is made up of **electro-magnetic waves**. These spread out from any light source, such as the sun, rather like ripples spread out on the surface of water after a stone has been thrown in. But light waves travel at tremendous speed.

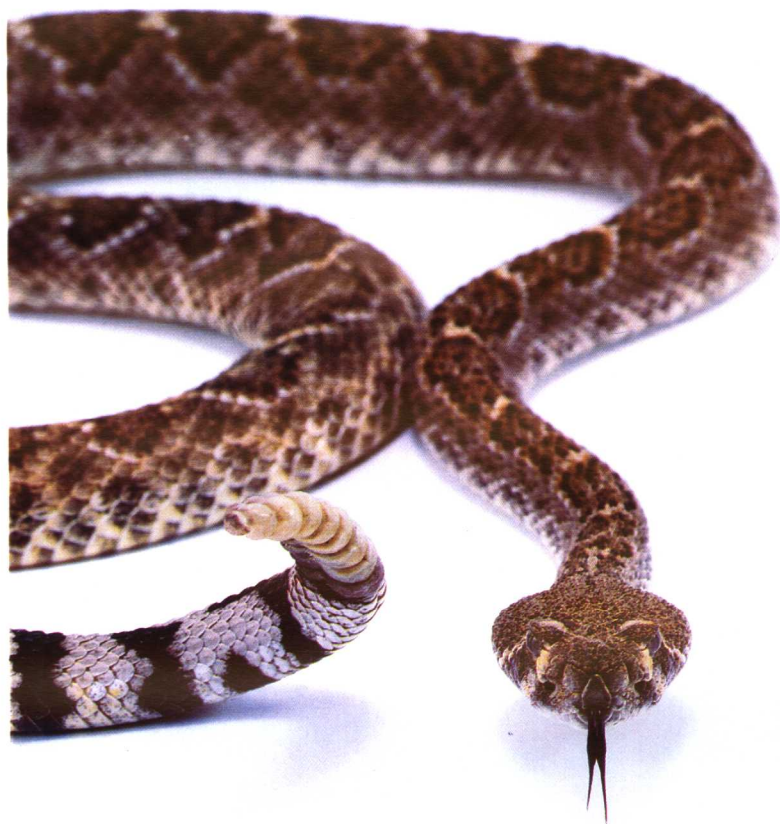
The distance between light waves, called **wavelength**, is what determines the colour of the light. The longest wavelength light that we can see is red and the shortest is violet. **Ultraviolet** has an even shorter wavelength but we cannot see it, although some birds and bees can.

要想明白色彩是怎么回事，首先要明白光的性质。光是由电磁波组成的。这些电磁波从太阳或诸如此类的光源向四周放射，就好像在水中投一石子后，水面上泛起的涟漪。但是光波的传播速度快得惊人。

光波之间的距离——即波长，是光的色彩的决定因素。肉眼所见的波长中红色光线的波长最长，紫色光线的波长最短。紫外线的波长还要短，但我们的肉眼看不见这种光线，只有某些鸟和蜜蜂能看得见。我们也看不见红外线，它比我们可见的红色光线的波长还要长，但我们能感觉到红外线的存在，因为红

The colourless rays of white light from the sunshine through the branches of Douglas Fir trees on a misty winter's morning. 冬日薄雾笼罩的早晨，白色阳光透过北美黄杉的枝叶射出的无色光线。





The pits on each side of a rattlesnake's snout, below its nostrils, are for detecting infrared rays. 响尾蛇的口鼻部两侧，鼻孔的下面有小孔，用来探测红外线。

Ivy berries in daylight look dull black to us but here, in the light from an ultraviolet lamp, they glow deep violet. Birds can see natural ultraviolet light and so ivy berries look bright to them in sunlight.

常春藤的浆果在阳光的照射下显得色彩暗黑，但在这里，经过紫外线灯光的照射，它们呈现出深紫色。鸟能看见天然紫外线的光线，因此，阳光照射下的常春藤浆果在鸟的眼里有着亮丽的色彩。

Neither can we see **infrared** which has a longer wavelength than red light. But we can feel some infrared because infrared is heat. A rattlesnake has special pits in its snout which are sensitive to infrared and allow the snake to "see" the warmth of a mouse's body, even in total darkness.

The sun's rays appear colourless to us but, in fact, contain all the colours of the rainbow mixed together. This is known as **white light**. When white light strikes a chalk cliff for instance, the cliff appears white to us because chalk **reflects** all colours equally. A lump of flint lodged in the chalk **absorbs** all colours equally and so looks dark grey or even black. Grass growing on the cliff is green because it reflects green light and absorbs other colours.

红外线有热度。响尾蛇的口鼻部有特殊的小孔，这些小孔对红外线很敏感，响尾蛇能靠这些小孔在漆黑中“看见”老鼠的体温。

太阳光给我们的感觉是无色的，事实上，它由彩虹的全部色彩所组成，我们称之为白色。举例来说，如果白色的光照到白垩峭壁上，峭壁就呈现白色，因为白垩能均衡地反射所有的颜色，放进白垩中的一块燧石能均衡地吸收所有的颜色，因此呈现出灰黑色甚至黑色。峭壁上的青草之所以是绿色，就因为它能反射绿颜色的光波，而将其他颜色的光波吸收了。







Paintbox Colours

颜料的色彩

Most of the colours that we see in plants, animals and minerals are due to **pigments**. These are chemical substances that absorb some wavelengths of light, while reflecting others. The colours we see are the wavelengths that have been reflected. Grass is green because it reflects green light, not because it is itself green. This can be proved by shining pure orange light onto grass. It no longer looks green because there is no green light for it to reflect.

The feathers of many birds are coloured with pigments and, in some, the amount of colour depends on what the bird has been eating. Flamingos eat **algae** and small water animals which contain a pigment that colours their feathers pink.

Many animals and plants produce pigments that are **soluble** in water. Soluble pigments are known as **dyes**. Sea slugs can squirt out a purple dye called gentian violet as a means of defence. And the brilliant crimson of a turaco's wing feathers is due to a dye called turacin which washes out in water.

Many of the dyes used to colour our food and our clothes are derived from plant or animal pigments.

我们能看见的植物、动物以及矿物质的大部分色彩都来源于色素。色素是在反射某些光线时吸收了其他光线的波长的化学物质。我们所看见的颜色是被反射光线的波长。草是绿色的，因为它反射绿色的光线，而并非因为它本身就是绿色。用纯橘黄色的光线照射青草就能证明这一点。青草不再显现绿色是因为没有供反射的绿色光线。

很多鸟的羽毛都含有色素，而且有些鸟的羽毛的色彩与它们摄取的食物有很大的关系。火烈鸟吃海藻以及微小水生物，这些食物含有能使火烈鸟的羽毛变成粉红色的色素。

很多动物和植物都能分泌出溶于水的色素，这种可溶性色素被称为染料。海参能喷射出一种叫做龙胆紫的紫色染料，并以其自卫。蕉鹃艳丽的翅羽来自一种叫做蕉鹃羽红素的染料，它能溶于水。

我们食品和服装染色时所用的染料大多来自植物和动物的色素。

Rocks coated with copper oxide, a naturally occurring blue pigment.

这些是表层附有氧化铜的岩石，显现天然的蓝色。



A Greater Flamingo preens its gorgeous pink feathers.

大火烈鸟用嘴梳理着其亮丽的粉红色的羽毛。



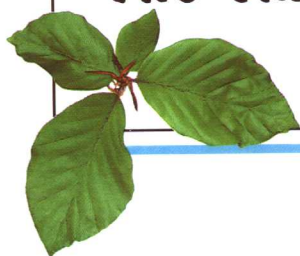
The crest feathers of Ross's Turaco are crimson, like the flight feathers on its wings.

中非的罗斯蕉鹃的羽冠呈深红色，色彩与其飞羽相同。



The Importance of Green

绿色的重要性



Young leaves of Beech are bright green when they first open in spring.

山毛榉的嫩叶在春天露芽时呈浅绿色。

Green moss growing in the cool shade of a damp forest collects all the light it can for photosynthesis.

在潮湿树林的阴凉处生长的绿苔采集全部的光以实现光合作用。

The Lettuce Sea Slug looks like a green leaf, and even photosynthesises like one. Microscopic particles of green plant material, called **chloroplasts**, in its body make sugars which the sea slug lives on. It does not need to eat.

生菜海参，看上去像一片绿叶，其光合作用也与绿叶相似。其体内含有一种在显微镜下才能看得见的绿色植物物质——叶绿体，海参靠叶绿体所合成的各种糖分生长，而不需要吃东西。

It is easy to think that green is the most important colour in nature. Vast areas of the natural world are green because green is the colour of leaves. We think of green as the colour of fresh natural growth. But, the fact that nearly all leaves appear green is an accidental result of the process called **photosynthesis**. This enables plants to use light energy from the sun to make the sugars which they use for growth. Photosynthesis is the basis for nearly all life on Earth. Plants rely on it for food and animals, in turn, rely on the plants.

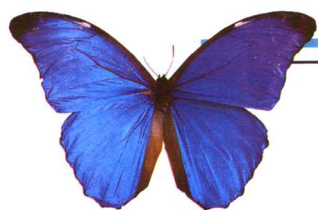
At the heart of photosynthesis is the green pigment, **chlorophyll**. It absorbs some wavelengths of light and uses their energy in the process of making sugar. But not all wavelengths of light are useful in this process, and chlorophyll reflects the useless wavelengths. In fact, green is the colour that is no good for photosynthesis and that is why leaves reflect it. All the lovely green that you see around you in the forests and fields is just waste light that plants cannot use.

绿色是自然界最重要的颜色，这一点不难想像。自然界的大部分地区都呈绿色，因为绿色是树叶的颜色。想到绿色我们总是想到蒸蒸日上的自然界的生长状态。但是，几乎所有的树叶都呈绿色其实是一种叫做光合作用的变化过程所导致的偶然结果。这种变化过程使得植物利用太阳能制造其生长所需的糖分。光合作用是地球上几乎所有生物生长的基础。植物靠它吸收养料，而动物又以植物为食。

光合作用过程之核心是一种绿色色素，叫叶绿素。它能够吸收一些光波，并用所吸收的光能造糖。但是并非所有波长的光线都能派上用场。叶绿素将用不上的光波反射出去。事实上，绿色正是那种因在光合作用过程中没有被派上用场而被树叶反射出去的颜色。在树林中、田野里，我们环顾四周时所能见到的宜人的绿色就是植物用不上的无用光线。







Iridescent Colours

斑斓变幻的色彩

The wings of a Morpho Butterfly flash purple and sky blue, depending on how the sunlight catches them.

大闪蝶的翅膀因阳光照射的角度所致，可以呈现紫色和蔚蓝色两种颜色。

Not all colours are due to pigments. When a beautifully coloured soap bubble bursts, it leaves only a drop of clear water. Obviously, the colours in a bubble are not due to pigments. Similarly, there are no pigments in a rainbow. The colours of a rainbow are produced by **refraction**. Each colour in white light from the sun is bent at a slightly different angle by the falling raindrops which act as thousands of tiny **prisms**. In this way, the colours are separated so that we can see them as bands of coloured light.

并非所有的色彩都来自色素。当漂亮的肥皂泡破碎之后，剩下的只有一小滴水珠。很明显，气泡的色彩非色素所致。同样道理，从彩虹里也找不到色素。虹的色彩来自光的折射。下落的水滴就像是成千上万个微小的三棱镜，来自太阳的白光通过小水滴时被有细微差别的多种角度折射，这样，七色光带被分解，因此我们才看到彩色的光束。

A European Kingfisher's brilliant blue and turquoise colours are produced by very thin layers of transparent material on the surface of its feathers. These strongly reflect the blues, while absorbing other colours.

欧洲翠鸟的羽毛看起来翠蓝透亮。其色彩来源于羽毛上所长的极为细小的透明物质薄膜。这种透明层在吸收其他颜色的光波时，对蓝色光波有很强的反射力。





◀ The iridescent feathers of these Purple Glossy Starlings gleam blue, green or purple depending on the angle at which the light strikes them. The colours shimmer over their plumage as the birds move.

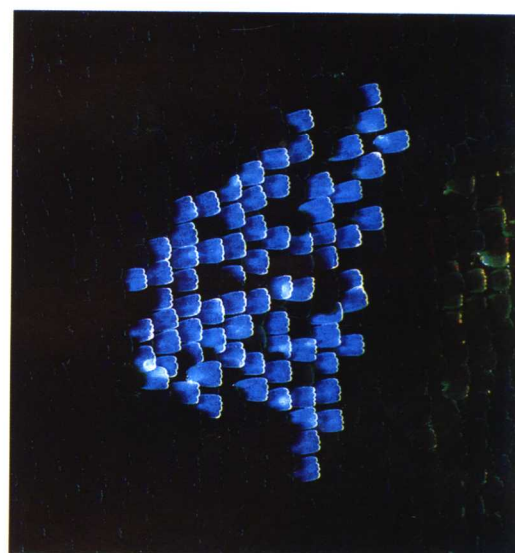
紫翅椋鸟华丽的羽毛因阳光照射的角度不同而呈现蓝色、绿色或者紫色。椋鸟处在活动状态时，其羽毛上交替闪现不同的颜色。

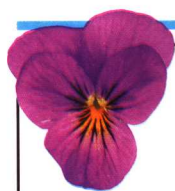
Many of the most beautiful animals do not use pigments to produce their gorgeous colours. The brilliant **iridescent** blues and greens of hummingbirds and kingfishers and of many **species** of butterfly are due not to pigments but to something called **interference**. The surface of the feathers of these birds, and the scales on the butterflies' wings, are built of microscopically thin layers of transparent material. These complicated and very precise layers reflect light of particular wavelengths strongly. Other wavelengths are reflected much less strongly because the layers cause the waves to interfere with one another, and cancel each other out. Trying to extract colour from a hummingbird's feathers would be as useless as trying to collect the colours from a rainbow by holding a jar to catch the drops beneath it!

很多最美丽的动物，其绚丽夺目的色彩都不是依靠色素产生的。蜂鸟和翠鸟以及许多种蝴蝶的羽毛蓝绿相间，深浅不一，光彩夺目，这都是由于光线的干扰所导致，而与色素无关。这些鸟的羽毛的表面以及蝴蝶翅膀上的鳞片上有多层细小透明的薄膜。这些纷然杂陈、色彩鲜明的薄膜对具有某些波长的光线反射力很强。对其它波长的光反射力较弱是因为各个层面之间光波互相干扰，互相抵消。想从蜂鸟的羽毛中提炼出色素，就像在彩虹下端着罐子接水滴来收集彩虹的颜色一样，都是徒劳无工的。

Many iridescent blue scales make up each of the blue flecks around a Small Tortoiseshell Butterfly's wings.

小龟背蛱蝶鳞片呈不断变幻的蓝色，层层鳞片构成其翅膀上点点蓝色的光斑。





Fancy Colours

花哨的色彩

Plants as well as animals wear fancy colours to advertise themselves. This pansy flower is advertising itself to bees so that they will come to visit it.

植物和动物都能身披耀眼的色彩宣传自己。这朵三色堇正以其色彩引诱蜜蜂前来拜访。

Animals that wear bright colours are like people who wear fancy clothes to a party. They want to impress their friends and neighbours. But animal colours are not just for parties. Many animals wear their bright colours all the time.

Very often, male birds are bright coloured while females are drab brown. This is because males and females do different jobs when it comes to rearing a family. The male's job is to make sure that there is enough food in the area around the nest for the parents and their

动物身体鲜艳的色彩跟人穿上华丽的服装去参加晚会有异曲同工之妙。他们都是为了以此向友邻炫耀。不过动物艳丽的色彩不仅仅只用于晚会上出风头。很多动物亮丽的色彩是终年披挂在身上的。

通常雄性鸟的羽毛艳丽多彩，雌性鸟的羽毛则呈暗褐色。这是因为成家后雌鸟和雄鸟的家庭分工有区别。雄性鸟的职责是要保证其栖息地有足够的食物

The Golden Pheasant male is brilliantly and conspicuously coloured. He spends his days strutting through his territory, chasing off other males....

雄性的锦鸡身着五彩锦衣，鲜艳夺目。它全天都在其领地昂首巡逻，随时将其他雄鸟驱逐境外……

...while the drab female Golden Pheasant is almost invisible when sitting on her nest.

……相比之下，暗褐色的雌鸟卧在鸟窝中时却难以被发现。



young, and to do this, he must chase away other birds of the same species which might eat the food. The colours of the male act like a painted signpost saying "keep off".

The bright colours of many male birds may also serve to attract a mate. For instance, gaudy male birds of paradise dance in front of females to display their colours. The Magnificent Bird of Paradise even plucks leaves from trees so that a shaft of sunlight can fall onto his iridescent feathers, making them shimmer in the darkness of the tropical forest.

Both male and female butterflies can be brightly coloured. Their colour patterns, like those of the birds of paradise, are a form of advertising. They tell other butterflies of the same species where to find a mate.

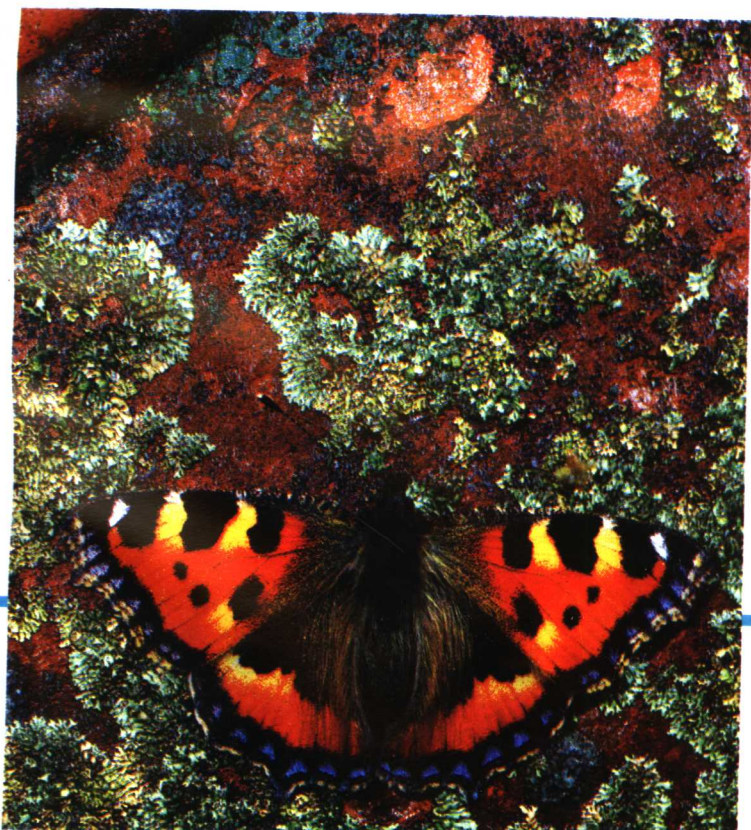
养活其配偶和子女。为了达到这一目的，它必须将可能会抢吃其食物的同类鸟驱赶出境外。雄性鸟艳丽的羽毛就像彩色路标一样告戒其他鸟“请勿入内”。

雄性鸟亮丽的颜色也用来吸引异性。比如，王极乐鸟中的雄鸟为了展现其艳丽的羽毛会在雌鸟面前翩翩起舞。王极乐鸟甚至能把树叶啄下来，让一束光线正好照在它们光彩夺目的羽毛上，使自己在幽深黑暗的热带雨林深处闪现。

雄性和雌性蝴蝶都可能色彩艳丽的羽毛。和极乐鸟一样，它们美丽的翅膀具有广告宣传的作用。它们以其色彩告诉同种蝴蝶，哪里能找到配偶。

A Small Tortoiseshell Butterfly has a distinctive colour pattern on the upper side of its wings. This pattern is recognised by other butterflies of the same species.

小龟背蛱翅梢上有独特的花纹，很容易让同种类的蝶辨认出来。



The colourful male Rock Agama Lizard makes himself even more visible by bobbing his head up and down to threaten other males. Female Rock Agamas are coloured quite differently from males and so do not get mistaken for rivals.

色彩鲜艳的雄性鬣蜥上下摆弄它的头部使自己注目，吓唬其它雄性蜥蜴。而雌性鬣蜥的身体颜色却大不相同，绝不会被雄性错当对手。



This Song Thrush is feasting on ripe Red Currants. Later, the bird will drop the currant seeds far away, helping the plant to spread.

画眉鸟正美美地享受红醋栗的甜汁。美餐过后，它会把果核甩落到很远的地方，助种子传播一臂之力。



Plants use fancy colours a lot. All the coloured flowers that you see in gardens and in the woods and fields are a form of advertising. The flowers have **nectar** "for sale". You might think that the nectar is free for any insect or bird to collect, but it is not. The "price" of the nectar is that **pollen** from the flower must be carried to other flowers. In this way, plants ensure that pollen from one plant **fertilises** the seeds of another plant. Seeds cannot grow unless they are fertilised.

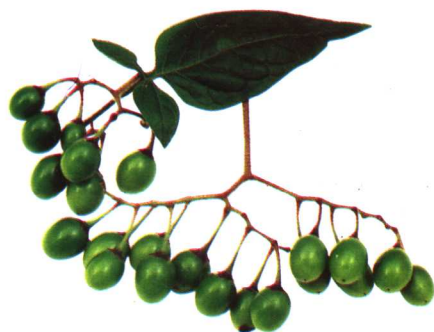
Some flowers reflect ultraviolet patterns invisible to us but visible to bees. The patterns are there to guide bees to the nectar.

艳丽的色彩对植物也大有用途。花园、树林以及田野中的万紫千红的花朵都是一种广告：花朵要“出售”它们的花蜜。也许你以为花蜜对那些昆虫或鸟类都是免费供应的吧，其实则不然。要得到花蜜，其“代价”就是将花粉运送到另一枝花上。这样，就能保证一株植物的花粉能给另一株植物的种子授精。种子不授精就不能生长。

有些花能反射我们肉眼看不见而蜜蜂能看得见的紫外线光波，正是这种光波引导蜜蜂去采花蜜。

Green berries of Woody Nightshade contain unripe seeds, so the plant keeps the berries unattractive to birds.

南蛇藤绿色的浆果里包着的是未成熟的种子，所以该植物让浆果保持对鸟没有吸引力的颜色。



As the seeds ripen, the berries turn red and succulent—an advertisement to birds to come and eat them.

等种子成熟以后，浆果果皮变红，肉嫩多汁——这是招引鸟前来啄食的一种广告宣传形式。

