Translated extract from

Jens Soentgen / Vitali Konstantinov (Ill.)
Von den Sternen bis zum Tau.
Eine Entdeckungsreise durch die Natur.
Mit 120 Phänomenen und Experimenten.

Peter Hammer Verlag, Wuppertal 2011
ISBN 978-3-7795-0291-3

pp. 7-45

Jens Soentgen / Vitali Konstantinov (Ill.)
From the Stars to the Dew:
A Voyage of Discovery Through The Natural World.

Translated by Sheridan Marshall

Science Makes Us Happy!

This is a journey through the natural world – straight through, from top to bottom. The journey leads from the infinitely large to the infinitely small, from macrocosm to microcosm. On the way there are remarkable and extraordinary things to see all over the place, to smell, to hear and to taste. The chapters of this book are therefore not written as neutral reports. They are tributes to the stars, the moon, the water and the earth.

Yet nature is shown here not from an esoteric perspective, but from the perspective of modern science. A contradiction? Many people believe that modern science only permits a neutral, impoverished view of the natural world, as free as possible from emotional concerns.

But has science really taken away nature's magic? Of course not! Modern science is not a cold theory-machine. Science does not just calculate things, it tells wonderful new stories. These stories are about things which everyone can see, about clouds, birds, mountains and seas, but also about earlier worlds and distant suns. Science is not only about economic, technical or medical applications. It has an enormous cultural and aesthetic vitality. It has discovered a new, undreamt-of beauty in many natural structures and creatures, and tells us things about them which are more impressive than the fantastical myths of the past. Science has, in a wonderful way, paid special tribute to the tiniest and most inconspicuous of creatures! It has opened up the depths of time and tells of figures of the earth and of life which engage the imagination every bit as much as the most powerful myths of bygone days! What is a fire-breathing dragon compared to the dinosaur

families! When science does refute old, poetic knowledge of nature it does not automatically replace it with an unfeeling series of formulae. But rather a new story comes into being. A newer, more beautiful magic replaces the old one. It is creative destruction, not just negation!

Those who are of the opinion that earlier generations enjoyed a more poetic understanding of the natural world have mostly barely engaged with pre-modern natural science and cosmology. It is already clear from Pliny the Elder's *Natural History*, or the myth-rich *Otia Imperialia* by the English scholar Gervase of Tilbury – to name only two examples – how repetitive and frequently cruel many of those myths were which are held to be enchanting today. Only a tiny proportion of the natural world was given any consideration. And how *small-minded* people of earlier times were towards many creatures! Not just many individual animals (e.g. lizards, snakes, bats, owls etc.), even whole landscapes such as mountains or moors were considered to be useless, provoking neither joy nor wonder, but rather *disgust*. Many things, for example cloud formations, seem not to have been noticed at all in the past.

The widely held idea that modern science is completely cold and unromantic derives from a very one-sided way of looking at things. A lot of people identify physics as 'the' science, or even just mechanics, a part of physics. The historical natural sciences, such as geology or cosmology, or perhaps paleontology and the theory of evolution, are ignored. On the other hand our society uses the sciences in a cold, one-sided way. Above all we use them as a productive force and harness them to the wagons of industry. They are required to produce ever new and better materials, synthesize new lifestyle drugs, even faster cars, even more efficient nuclear weapons and fighter jets or

even shinier paint. It is a bit like trying to reduce music to mathematics. The sciences can do better than that. In the future they may teach us how to perceive things more sensitively again, to observe the cosmos with new, more intensive feelings, to discover ourselves anew! This kind of use of the sciences does not directly lead to making money and does not promote growth in the economy. Instead it stimulates the imagination, schools us in observation, and promotes joy and happiness.

The sciences can *liberate* our experience of nature and enrich it in unexpected ways. *We* can look at the natural world with much gentler and more sensitive eyes than even the most open and lively minds of antiquity or modernity! We can discover in nature a deeper purpose and a whole new, heroic beauty to which all people before us were blind. We have many more reasons to value and celebrate nature than all our ancestors. What did people who lived before the 16th century know of infinity, asks Blaise Pascal in his *Pensées*. Modern science places all creatures great and small, and all natural formations, in a whole new context – much more exciting and enlightening than in most accounts from antiquity and the Middle Ages.

The natural world in its endless manifestations, from the enormous things right down to the insignificant ones! In order to celebrate it, each chapter includes suggestions for observations and experiments. One would not believe that anything would depend on looking for oneself anymore, since everything must already have been discovered. And yet precisely those things that are banal and ubiquitous are full of wonders, full of mysterious phenomena! Today there is not less but *more* to discover than ever before. Beneath the layer of ash with which habit and despondency have buried the world

lives the new, the beautiful. Just one breath and the layer of grey is gone.

The experiments should be regarded as invitations to discover new things – and two strategies stand ready for this: looking and testing. Looking is a way of finding out about things that does not alter anything, testing is a form of alteration that seeks to find out about things. Both strategies of discovery are indispensable for scientific progress, both are something we are born with, as curious beings. Children already look, children already test. Looking and testing are integral to the sciences, and are varied, improved and perfected in countless forms. The oldest science of investigation is astronomy, the oldest and still the loveliest science of testing is chemistry. Investigative sciences based on fieldwork and test-based laboratory sciences determine now as ever the structure of the sciences, although intensive collaboration has developed in between the two. Laboratory sciences have extended into the field and what was formerly purely fieldwork has reached the laboratory. The science of looking has cultivated complicated measuring techniques and the test has given rise to the scientific experiment, which systematically dissects a situation into its components and combines these with one another in a specific way. Despite all the technological advances, the similarities between scientific research and the ways in which children find things out are noticeable to all those who are observing or involved in such work. When Alfred Hershey, the American microbiologist and Nobel Prize winner, was asked how he envisaged the scientist's ultimate happiness, he said: 'To have an experiment that works, and to do it over and over again', which describes precisely the researcher's childlike drive. In the first generation of microbiologists, the dictum came into being that

someone was in ‘Hershey-heaven’, when he had an experimental system that was working well.

Our experiments and phenomena are conducted without professional equipment. No telescopes, no microscopes, no test tubes, not even binoculars or a magnifying glass. Not because I have anything against instruments. It is just more instructive to look and to listen freely with our senses first of all. Instruments are only worthwhile after this process.

There are many connections which the observer is better able to recognize with the help of technology, and others that are only perceived by laying technology aside. Everyone knows that even with a basic pair of binoculars you see phenomena in the night sky that are not visible to the naked eye. It is much less well known that there are also scientifically relevant phenomena which you *only* see when your senses are disarmed. It is not just that they become less clear with an instrument – they completely disappear. You as good as never see shooting stars when you look at the sky through a telescope. But anyone who regularly walks along looking up at the night sky with their bare eyes often sees them, and now and then is even lucky enough to see a real fireball. Even such a simple and cosmologically important a phenomenon as the Milky Way is not visible through binoculars. On the other hand, it is easy to see the Milky Way with one’s bare eyes – as long as it is not obscured by stray light.

Even today, science continues to have a lot to do with sensory perception! Outside, in the forests, in the deserts, in the mountains, on the oceans, the scientist becomes a Red Indian, alert to the most subtle phenomena. The most insignificant things tell him whole stories which

remain hidden from other people. He has a particular sense precisely for the insignificant. Many phenomena can only be seen in the light of the afternoon sun, and not in artificial light, others are only perceptible in moonlight.

Anyone who thinks that scientific insights obtained through mere observation and simple primary school mathematics could not be of any importance, is wrong. Half of all central scientific theories were developed without high-tech apparatus and without advanced mathematics – just think of the classic astronomy of the solar system, the classic theory of evolution, the discovery of geological deep time or the theory of continental drift. Insights do not increase in proportion to the complexity of the apparatus and the sophistication of the mathematics being used.

It is even justified to ask whether many scientific achievements might have been impeded if the researchers in those days had had the capital-intensive equipment which is taken for granted in the study of physics and chemistry today. If Nicolaus Copernicus, whom we thank for the discovery that the Earth revolves around the Sun, could have managed his ephemerides, the schedules of his observations of the planets, using a high-performance computer, then his revolutionary book might never have been written. It does not matter to a computer whether it has to carry out many highly complicated calculations or a few simple ones; it delivers the results in milliseconds. And so Copernicus would never have felt the need to replace a complicated system with a simple one. He did not even possess a telescope!

Even today, now that the sciences have become heavily technologized, finely tuned perceptive faculties are indispensable in disciplines such as geology, biology, geography or meteorology, to

name but a few. Looking after these sensory capabilities is more important today than ever.

It is therefore true for this book that the more we rediscover how to look, to listen and to feel, to taste and to smell, the deeper our insights will be. And when now and then we need something to help us, it is something that comes out of the kitchen or the cellar and is readily available at home, or can be purchased inexpensively in the supermarket or DIY shop.

In this respect the experiments are modest. Admittedly they sometimes require patience and imagination. It is important to try out each thing and to improvise when something doesn't work. The real natural historian is not someone who lets themselves be forced into anything, but someone who cleaves their own way. He is an empiricist. You could also say that he is a pirate. Both words come from the same root, that of the Greek word *peiran*, which means something like to try or to venture. The scientist is also tempted by newness, not the old routine. As Benjamin Franklin, the American scientist and statesman aptly said, he must therefore be able to 'saw with a drill and to drill with a saw.'

Mathematics is an indispensable tool in most scientific disciplines. When the researcher combines mathematics with clearly defined concepts it helps them to pose more exact questions and to answer them more clearly. But again it is not the case that the more complicated the mathematics, the more impressive the result. Even multiplication tables, together with some geometry, massively increase the possibilities for posing and answering questions. Many meaningful discoveries were made thanks to the simplest numerical calculations – Mendel's laws of heredity, for example. Our observations and

experiments also make use of mathematical or geometrical connections, although nothing more than basic arithmetic and a little bit of geometry will be called for. I want to show how much anyone is capable of, just with the most simple of mathematics. In contrast to mathematics, I have, every so often, included reports about wonderful occurrences, and about the solace afforded to us through the experience and observation of the natural world. They demonstrate what *heights* we can attain through the experience of the natural world.

We begin with the big things, and end with the little ones. If you want to put things in order, you need some sort of scale. We experience just how exciting this kind of journey can be when we read accounts written by the generation of researchers in the 18th century who discovered the night sky and the microcosm at the same time. The German philosopher, Gottfried Wilhelm Leibniz, witnessed some of the great discoveries of that time, which continue to shape our understanding of the natural world to this day. According to his grand vision, *everything* is full of worlds, 'every tiny piece of matter is a garden full of plants and a pond full of fish,' as he writes with passionate emphasis in his work, *The Monadology*. He believed that every world is permeated by smaller worlds, which are no less beautiful than ours. *Nature consists of an infinite variety of worlds which inhabit one another*, a powerful, interwoven organism – this accounts for its infinite depths. This is why we can never grow tired of looking at it.

The idea for this book came about after a holiday which we spent not travelling abroad, but at Lake Starnberg in Munich. Rose Island was a particular highlight for us. We travelled to the island by ferry from the Feldafing shore – it's so close that you could swim across. Depending on the weather, we then picnicked on the island.

We always brought something home from these outings: a small flower picked by the children, an unusually shaped stone, a leaf from a tree, a tissue with dust on it, which, according to the newspapers, had blown in from the Sahara and settled on the tables and chairs. And photos of course. Blurred photos where nothing is visible apart from the sky, photos of pebbles, photos of the lake and the island.

One evening I arranged the pictures and the things we had collected on the table, not chronologically, but according to the size of the objects on the pictures. First the sky photos, then a watercolour of the lake, a photo of the island, and one of a tree, right down to the sample of Sahara dust. I realized that the series lying in front of me constituted a representative journey through the whole of the natural world – from top to bottom, from the huge things right down to the tiny ones. What we experienced on our holiday was in fact also a tour of the world, just not horizontally, not 'round the world', like a modern aeroplane flight, but 'through the world', from top to bottom.

This history owes its existence to my starting point on Rose Island in Lake Starnberg. But the journey that I describe here does not lead us into Bavaria. Instead we are taking ourselves for a walk through nature and the natural sciences. May it lead to enthusiasm for the sciences and a love of nature! We can begin the journey from any place where we have a sky over us, water in front of us, and earth beneath us.

1 Stars Over the Lake

If you look over towards the Alps from Lake Starnberg on a clear spring night, towards the south, you should detect a large, prominent constellation on the left hand side: this is Orion. If you observe it over a longer period you will notice that it does not remain still, but changes position: over the course of a single night it ascends, eventually reaching its highest point in the sky – its culmination – and then descends again. But it is always visible in the south. Orion's middle is decorated by three bright belt stars, with three smaller stars around it; the framework consists of two 'foot stars' and two 'shoulder stars'. People were already familiar with this constellation in Ancient Babylon, where it had names such as the 'Heavenly Shepherd', the 'Great Hunter' and the 'God of the Great Door'. Orion is so noticeable because it always seems to stand over the horizon, upright and immense. It travels a small distance – as though climbing an imaginary mountain – always from East to West, but never moves too far away from the horizon. This is what makes it so memorable.

I have Orion to thank for an experience which, even though modest and hardly sensational, nonetheless moved me deeply. At one time in my life I was working in southern Brazil, in a town called Porto Alegre, a long way below the Equator and just about as far from the South Pole as we are from the North Pole. When it is summer in northern Europe, it is winter there, and vice versa. I was staying in a hotel; one night, when I woke up at three o'clock and couldn't get back to sleep, I took the lift up to the 14th floor. There was a 'swimming pool' there – a small tank of water, 2m by 4m, which was somewhat remarkable at that height. White plastic chairs stood around the pool. Bats flew around the building, chasing each other in the spaces between the hotel and the neighbouring buildings. The night sky arched above it all, presenting a completely unfamiliar sight, here in the south of Brazil. Directly above me, in the middle of the sky, I saw a huge

rectangle, which seemed to me to be a sort of boat. There was even a rudder. Which constellation could it be? I did not know it. Suddenly I worked out that it was Orion. It stood not at the southern edge of the sky, however, but in the middle of it! Why? I realized that I had slid away from Munich halfway down the globe, always towards Orion, and kind of through his legs, underneath him, carrying on until I was now seeing him from beneath instead of from the front. All at once I knew that I really was far away. I also knew the direction I would have to travel in order to go home again. And for the first time in my life I had really experienced that the Earth is a *ball*, and in fact not too enormous a ball.

I thought about sea-farers having this same experience during the period of the great discoveries – Orion rising ever higher as they sailed southwards, and new, unknown stars coming into view at their feet – the southern night sky, which had hitherto been hidden to the inhabitants of the northern hemisphere.

I believe that this is the most wonderful thing that the night sky gives to people: it tells us immediately where we are on Earth. Whether 'up' in the north, in the middle, or 'down' in the south. The impression that a person has of the stars varies according to their location. So the night sky can tell him in which direction he must go in order to find his way home again. The stars are the oldest and most important signposts that we have. They helped humanity's most famous wanderer, Odysseus of Ithaca, to find his way home.

They tell the traveller in a totally poetic, sublime way that he is moving around on a ball. A ball which is soaring through space. And they show him the place where someone is waiting for him.

1 Night Vision

SITUATION: in a dark room; outside, on a starry night

If you want to see well at night you must familiarize yourself with the peculiarities of seeing in the dark. This is much easier to do in a familiar environment than outside looking at the night sky. The simplest thing to do at first is to observe what happens in your bedroom when you turn the light out at night. At first you will see absolutely nothing, (it must of course be absolutely dark with no light shining in from a street lamp). Now try to see a white shirt hanging on the wardrobe. You make an astounding observation: when you look at it directly, the shirt disappears. Yet if you look somewhere else and peer at the shirt out of the corner of your eye, it is easily visible. Night vision clearly follows other rules to vision in broad daylight. Whenever you look more closely at anything at night, it disappears; if you look past it, it materializes. So there is a paradox here, that you can actually see more by avoiding looking at things directly – a situation which has many parallels in life. It is fun to make things disappear by looking at them and to make them appear again by looking away. Outside, under the night sky, you realize that the fainter stars are also best seen by looking past them, when you allow your gaze to wander.

2 Star Charts

SITUATION: outside, on a starry night

EQUIPMENT: this book

(1) If you live in a town you orientate yourself in the first instance in relation to a few important places, from which the situation of other streets, buildings and locations can be inferred. Finding your way around the night sky works in a similar way. Maps are helpful – and maps of the stars have been produced accordingly. They do not show everything in the sky, as they dramatically simplify things like on a tourist map, but for this reason they are ideal for a first orientation. Just as a tourist map shows important places, widely visible buildings and connecting roads, star charts show important constellations and bright stars, and show how you find one in relation to another. They are snapshots, since the night sky is always moving over our heads, even if very slowly. It is helpful always to observe the sky from the same standpoint. That way you recognize the constellations not only by their shape, but also by their height and the place from which they ascend. Our four star charts show what there is to see in the evening sky in spring, summer, autumn and winter. They fit with the given dates but are still usable two or three weeks before or afterwards. There are also more precise charts which are calculated for every month or even for every hour – the four seasons are enough for a first impression here.

(2) Looking south is the recommended direction for observing the stars. No compass is required since the polestar was friendly enough to position itself exactly in the north. You can easily find this star with the help of the Plough (also known in the USA as the Big Dipper) (see fig. 5). When you have found which way is north, you also know south. South is where the sun reaches its highest point at midday. The stars also culminate in the south.

(3) While a town plan is held in front of you so that the town lies ahead, it is different with a star chart. The stars shine above you, so you hold the star chart high in the sky in order to orientate yourself. In contrast to maps of the land, on star charts, east is left and west is right. If you hold the chart like a little roof above you in the night sky and make sure that north, south, east and west are pointing in the corresponding geographical directions, then every point on the chart should correspond with a point in the actual sky. But don't expect the chart and the stars to be on the same scale. Not all visible stars are represented on the chart. And the visibility is not always good enough to ensure that you can find all the stars on the chart in the sky! In addition, the constellations are on a much larger scale in the actual sky than the chart leads you to expect. The chart is a projection, and while the night sky is curved, the chart is flat. It can only be an aid which at some point you will replace with more detailed charts and, once you have found your way round the night sky and know where everything is, will eventually be able to lay aside.

(4) The charts show only a selection of constellations and stars, primarily those that can still be seen well in a town, or near a town. The light pollution above towns today means that it is only possible to see a small fraction of stars and constellations. The constellations which are well known from newspaper horoscopes – belonging to what is known as the zodiac – are unfortunately mostly indistinct and only seldom visible on moonless nights in calm, clear conditions. For that reason they have either been completely left off our maps or just barely outlined. Only the line upon which they lie, known as the ecliptic, is always shown as a dashed line. The planets and the moon are in motion along this line. If you see a particularly bright star in the area of this line, shining clearly, without flickering, it is most likely to be a planet. On summer nights the ecliptic and the constellations of the

zodiac are rather low, around the horizon. By contrast in winter they stand very high in the sky. The Milky Way is also shown on the charts, going straight across the pictures, although due to the high levels of light pollution it is rarely clearly visible. The zenith or high point in the night sky is marked on all the charts with a cross. Some stars have names; many of the names are of Arabic origin, since after the fall of the Roman Empire astronomy was first taken up by the Arabs. It was they who translated and disseminated the old Greek manuscripts.

(5) Whereas distances on conventional maps are given in kilometers, this makes little sense in relation to the night sky. Distances here are measured as angles. The entire visible hemisphere of the sky encompasses an angle of 180 degrees. The zenith is found directly over you at the highest point in the sky. Zenith and horizon form an angle of 90 degrees.

(6) There is a simple correlation between the more familiar measures of meters and centimeters and angular measurements: observed from a distance of 57.3 centimeters, 10 centimeters correspond to exactly 10 degrees. (Because the circumference of a semi-circle amounts to πr, where π = the value of Pi = 3.14 and r = half of the diameter = radius. When you work out this formula with a radius of 57.3, you get exactly 1.8 meters. So 180 degrees at this distance spans 1.8 meters, meaning that 10 centimeters are the same as 10 degrees).

(7) The distance of 57.3 centimeters is more or less an arm's length – it is slightly different for each person. Experiment with how far you have to spread out your fingers to achieve a distance of 20 centimeters. This span, again seen at arm's length, corresponds to around 20 degrees. The thickness of the little finger (between one and two centimeters) corresponds to between one and two degrees. For orientation purposes: the diameter of the disc of the moon – and the Sun – amounts to half a

degree. You can cover them up with the tip of your little finger. For beginners, *directions* are more important than quantitative distances, and these do not need to be very precise. In a sense, the constellations 'point' to one another, and these broad directions are very helpful. They are indicated on the star charts and largely originate from the Plough.

(8) The Plough belongs to the constellation known as Ursa Major or the Great Bear – its stars are the brightest in the Great Bear. It is visible somewhere in the sky during the whole year, always in a northern direction. On spring evenings you find it high up around the zenith, in the summer it is in the north-west at a medium height between horizon and zenith, in autumn low down on the horizon, and in winter it is in the north-east, again at medium height. If there is one constellation that everyone knows, it is this one. The first two and last three stars of the Plough – with the Arabic names Benetnash (also known as Alkaid), Mizar, Alioth, Megrez and Dubhe – are all around as bright as each other. Incidentally, they are all second magnitude stars, all even brighter stars belong to the first magnitude. Four stars form the body of the Plough and three form the handle. The two medium-sized stars in the Plough are called Phecda and Merak. They shine somewhat less brightly. At the bend in the handle, very close to Mizar is the star Alcor – Mizar and Alcor are sometimes called the 'horse and rider'. Alcor is a well-known measure of eyesight: whoever can see it without glasses has good vision. The Plough is a good starting point for walks through the night sky – it can be used like a central monument in a town to find easy routes to other constellations, and by and by can help you to find your way around.

3 Spring Stars

SITUATION: mid-April, around 10pm (11pm DST)

EQUIPMENT: this book

(1) Starting point: the Plough. When you draw a line between them and extend it upwards, the two foremost stars of the Plough point towards the Pole Star, which is found at the tip of the Little Bear's tail. The dragon coils itself in between the Great Bear and the Little Bear. If you extend the line of the Plough's two foremost stars downwards, you come to Leo, around the same distance away. Its head is reminiscent of an inverted question mark and the dot of the question mark is the star Regulus.

(2) If you extend the arc of the elevated part of the Plough backwards you come to a first magnitude star, the orange-coloured Arcturus, which belongs to the constellation of Boötes, the hunter. In America this constellation is also seen as an ice cream cone. Directly adjacent to it is the so-called Crown.

(3) If you extend the arc of the plough handle even further you arrive at the star Spica in the constellation of Virgo. This star lies on the path of the planets, a course followed by all planets and – with certain variations – the moon. The sun also moves along this trajectory during the day, known as the ecliptic. The constellations found along the ecliptic are those which turn up in horoscopes. They are not among the most impressive constellations – most of them are quite unspectacular.

4 **Summer Stars** (Fig. 7)

SITUATION: end of July, around 10pm (11pm DST)

EQUIPMENT: this book

(1) You have to stay awake for a long time in summer if you want to see the stars – there's no point in trying before 10pm. The temperature is much more pleasant though, and a lovely summer's night under the stars is always a pleasure. What is there to see?

(2) Directly above your head is an extended triangle of very bright, striking stars: the so-called Summer Triangle. One of the triangle's corner stars is called Deneb, part of the prominent Cygnus constellation. Cygnus flies right along the plane of the Milky Way, although you can only see the Milky Way on very clear nights away from brightly lit towns. The second star of the triangle is Vega, belonging to the Lyra constellation. The third star is Altair which also lies in the middle of the Milky Way. A reddish star called Antares shines and sparkles low down in the south, part of the Scorpio constellation.

(3) An equally quick find during the summer (but also in winter, since this constellation is visible all year round) is Cassiopeia, the sky's great 'W' shape. The Greeks identified it as a sigma (Σ), their letter 'S'. You find Cassiopeia by continuing to follow the direction of the two foremost stars in the Plough beyond the Pole Star. It is always in the north and rotates around the Pole Star, like the Plough.

5 **Autumn Stars** (Fig. 8)

SITUATION: mid-October, 10pm (11pm DST)

EQUIPMENT: this book

(1) From Cassiopeia, which stands quite high in the sky in autumn, it is easy to find the square of Pegasus, which is connected to the star chain of Andromeda. Near Andromeda something extraordinary can now be seen: the Andromeda Nebula, lying above the star called Mirach. In astronomy circles this nebula is also referred to as M31. It is a fleck of light which is only visible under good observational conditions. This fleck of light is a galaxy, the Andromeda Galaxy.

(2) In autumn the Plough sits very low down over the northern horizon.

6 **Winter Stars** (Fig. 9)

SITUATION: end of January, 9pm

EQUIPMENT: this book

(1) Winter is the best time to observe the stars, when the days are short and the nights are long. On the other hand it is painfully cold outside … In a south-east direction (in December around 10pm), in the south (in January around the same time), or in the south-west (in February), you find the prominent constellation of Orion.

(2) Observe Orion from the same place over a longer time; you will see that he slowly ascends and then descends again. And almost all the other stars ascend with him, culminate – achieve their highest point – and then sink again. They rise from the east, culminate in the south and sink in the west – exactly like the Sun.

(3) Extend the belt stars of Orion to the left and you reach the constellation of the Great Dog, Canis Major, which includes Sirius, the brightest star in the night sky. The Great Dog and Sirius are especially interesting: we have already seen that the stars come up in the east. New stars come up in the east throughout the night, until dawn, while other stars go down in the west. And in the course of the year new stars are continually becoming visible in the mornings. In the ancient world, Sirius became visible in the dawn sky for the first time at the end of July, appearing in the already lightening morning sky just before the Sun came up and outshined the stars. Sirius therefore heralded the hottest period of the year, the so-called 'Dog Days'. Many ancient astronomers believed that the summer days were so hot because the fire of Sirius mixed with the Sun's light and dramatically strengthened it. For the Ancient Egyptians the morning ascent of Sirius marked the beginning of the annual flooding of the Nile and the hottest period of the year at the same time. We still refer to Dog Days, and in Russia the

summer holidays are even named after the star – they are called *kanikuly* (from *canis*, the Latin word for dog).

(4) Above Orion to the right is perhaps the most beautiful constellation of all, the Seven Sisters, or Pleiades. As the Nebra sky disc, which was discovered some years ago in Saxony-Anhalt, proves, this constellation was already attracting attention during the Bronze Age. The Pleiades are known around the world, often by different names. In Germany many people believe that they are the Little Bear.

(5) Between Pleiades and Orion is a large 'V'. This is the most prominent part of the constellation of Taurus, whose red eye is formed by the star Aldebaran. The bull belongs to the Zodiac and lies across the ecliptic – the path followed by the planets, the moon and the Sun.

7 Count the Stars

SITUATION: a starry night in a town; a starry night out of town

EQUIPMENT: cardboard, scissors, pair of compasses, string

(1) An old lullaby asks whether the child knows how many stars there are in the sky; the Lord God has counted them, says the song, reassuringly. The ability to count the stars is an important source of comfort in an ever-changing world: at least as far as the stars are concerned, things have remained the same.

(2) But how do you count the stars? It is difficult, if only because you never know whether you have counted the same star twice, or missed others out altogether. There is a trick which makes it easier. You define a small section which you can easily manage, count the stars there, and then calculate the whole. To do this you make a small hole which makes one percent of the night sky visible. This hole is quickly prepared using a pair of compasses, scissors, a piece of card and some string:

(3) Take a piece of card and draw a circle with a diameter of 10 centimeters on it (i.e. radius of 5 centimeters). Cut the circle out. Use the point of the scissors to make a small hole in the frame, (which might need trimming to make it more manageable). Thread a piece of string through the hole and fasten it with a knot. Measure a distance of exactly 35cm along the string, and mark this length, for example with another knot. Cut the string 2-3 centimeters after the knot.

(4) It is relatively easy to count the stars in the section of night sky that is visible through the frame, when observed at the distance measured by the length of string. Through the circular hole in the frame you see exactly one percent of the night sky. Hold the cardboard frame with the hole in the middle in one hand and the cord in the other, keeping the

end next to your eye so that the distance is right. No wobbling! Now count the stars that you see and multiply the result by 100. You can get a more precise result when you observe different sections of the sky through the viewfinder, count the stars in each one and take an average.[1]

(5) In counting the stars, the budding stargazer will make a surprising discovery: we cannot see an infinitely large number of stars in the night sky, only a few hundred. Even on clear nights, the sky is so illuminated by the artificial lights shining from our towns and houses that only a fraction of the stars are visible. In many places it is already impossible to see the Milky Way. Many people may think that this does not matter. Most astronomers see things differently. They believe the sight of a resplendent night sky to be a wonderful experience, to which everyone has a right. Whoever sees the shimmering band of the Milky Way arching above a clear night sky and feels the remarkable power shining out from all the luminous stars, has to agree with them.

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[1] How is it possible to see exactly one percent of the night sky using this device? In brief, here is the formula: a hemisphere with a radius of 35 centimeters has a spherical surface area of $2\pi r^2$ Where π = figure Pi = 3.14 and r = radius = 35 centimeters; in our case 7693 cm^2. That would be 100 percent of the sky. One percent of that is 77 cm^2. If you want this area as a rectangle, then you could use one with, for example, sides that are 7.7 cm and 10 cm long. If you want the one percent as a circle, which is not necessary, but practical, then the formula you use to calculate the surface area is πr^2. Now you just have to calculate which radius gives the desired area of 77 cm^2. If you work it out you will find that it comes out as not quite 5 centimeters, but almost.