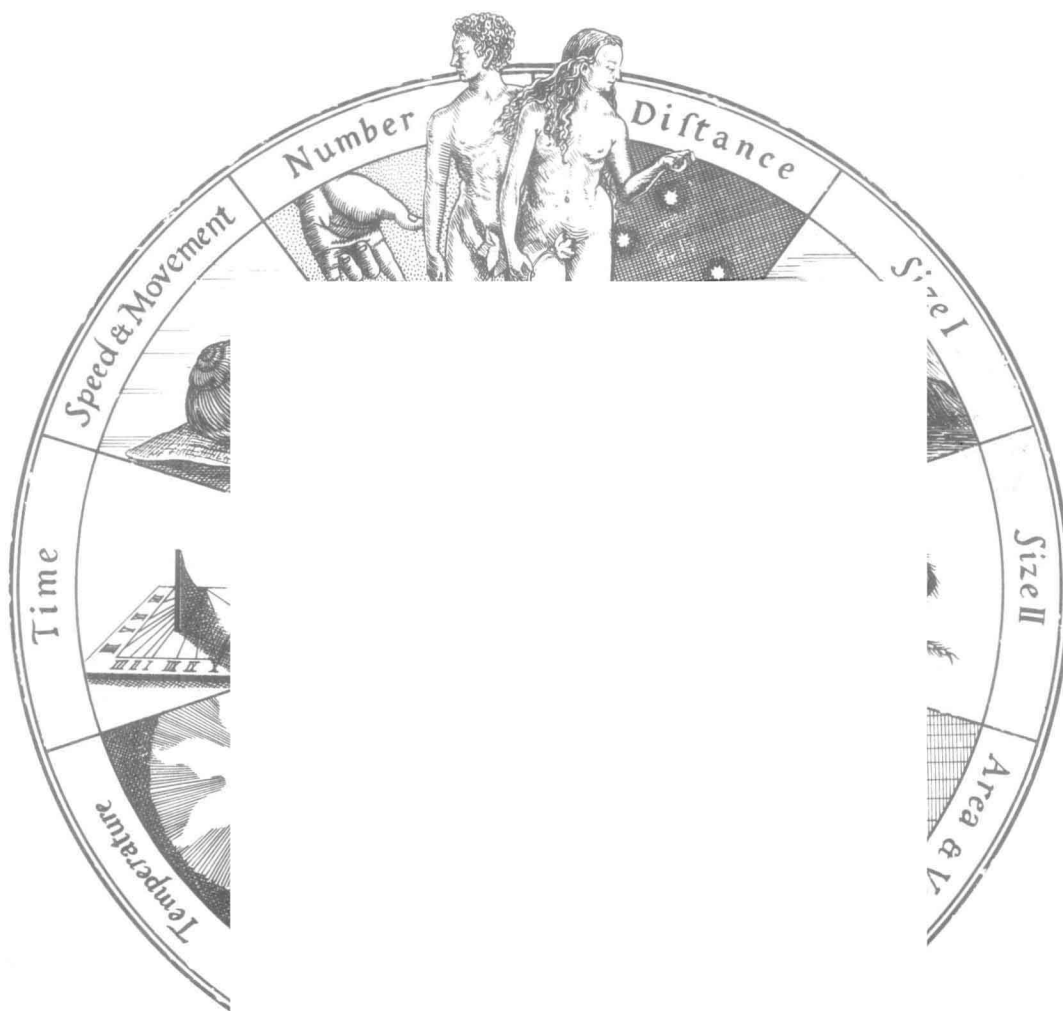


The Book of COMPARISONS



The Book of COMPARISONS

of distance, size, area, volume, mass,
weight, density, energy, temperature,
time, speed and number
throughout the universe

by the Diagram Group

SIDGWICK & JACKSON
in association with
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FOREWORD

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“Comparisons” is an exciting visual guide to how man measures—and measures up to—his universe. By making comparisons between like and like and between like and unlike we can evaluate the different properties of the known world.

Man has devised many units and scales of measurement, and **“Comparisons”** brings these together in one handy reference volume, pointing out differences from system to system and providing methods of conversion.

Most readers are familiar with the excellent “Guinness Book of Records,” which has for many years recorded the extremes of the human and physical worlds.

“Comparisons” displays and relates not only extremes, but also presents what we encounter in everyday experience.

To make this wealth of information easier to understand and remember, the artists and editors have created hundreds of illustrations and diagrams, all accompanied by concise, explanatory captions. This technique makes it possible to see at a glance and to appreciate fully comparisons that are not readily grasped from photographs or prose alone.

The originality of **“Comparisons”** will, we hope, both fascinate and inform, and also stimulate every reader to make further comparisons of his own.

The Diagram Group

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Dedication

This book is dedicated to: Tom McCormack, who thought of the idea; Len and Elkie Shatzkin, who introduced Tom to the Diagram Group; Ruth Midgley, who had to work harder than she had ever done before; and Patricia Robertson, who brought up four children single-handed while Bruce Robertson was too busy to come home

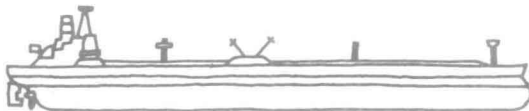
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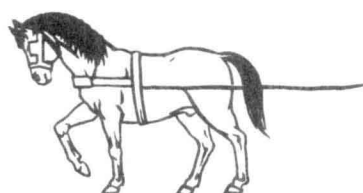
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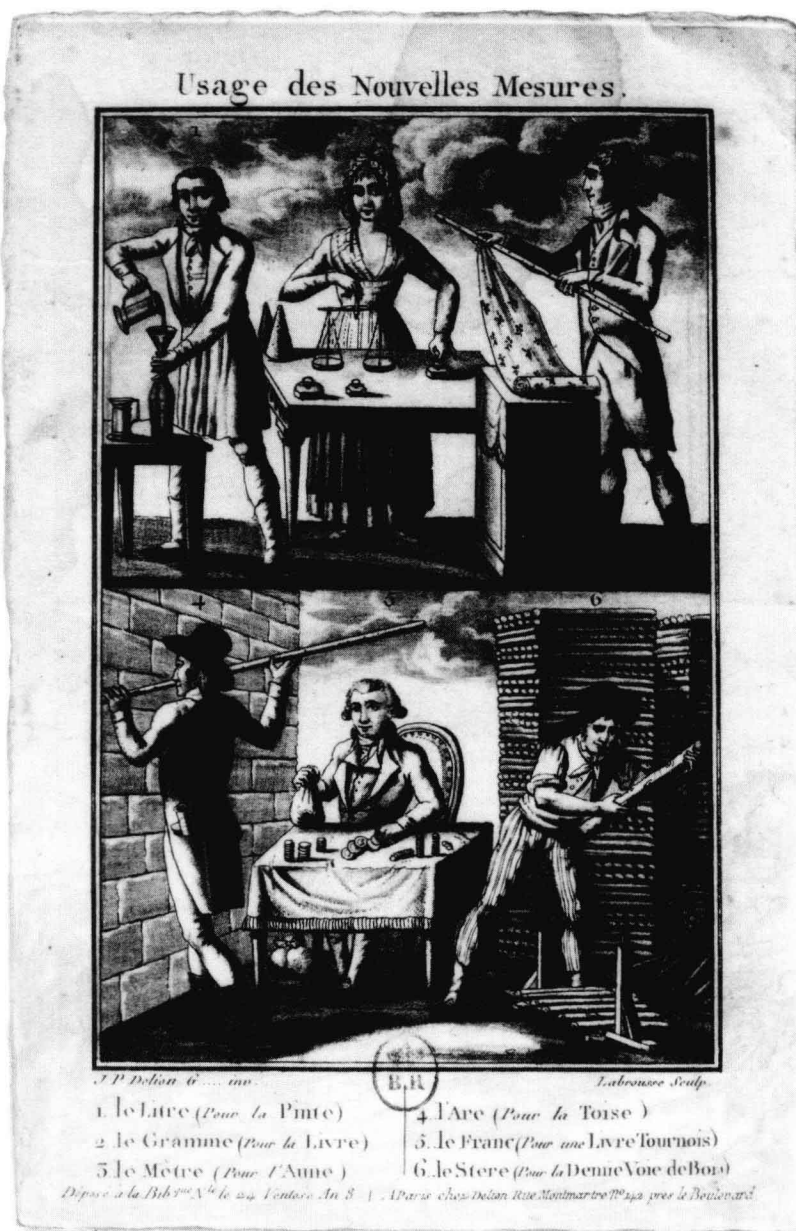
CHAPTER 1



Confirming the length of the rood, an old linear measure, by lining up and measuring the feet of the first 16 men out of church—from Jacob

Köbel's *Geometrey von künstlichen Feldtmessen* of 1598 (Science Museum, London).

DISTANCE



A contemporary French print illustrating the use of the new metric measures introduced in the wake of the French Revolution of 1789 (Photo: Bulloz).

MEASURING DISTANCE

The width of a finger, the length of a foot, the distance covered in a stride, and the length of a furrow ploughed by a horse are ingenious linear measurements from earlier times. Today, demands for greater precision and standardization are resulting in a much wider acceptance of the scientifically based metric system.

The body rules below

Illustrated are two ancient measuring systems based on the human body.

Egyptian measurements

- A Digit, one finger width
- B Palm (= four digits)
- C Hand (= five digits)
- D Cubit, elbow to finger tips (= 28 digits, 20.6in)

Roman measurements

- E Foot, length of one foot (subdivided into 12 *unciae*, hence our inches)
- F Pace (= 5 feet), of which 1000 made up the Roman mile (*mille passus*)

US customary/imperial units of linear measurement

- 12 inches (in) = 1 foot (ft)
- 3 feet = 1 yard (yd)
- 1760 yards = 1 mile (mi)

Metric units of linear measurement

- 10 millimeters (mm) = 1 centimeter (cm)
- 100 centimeters = 1 meter (m)
- 1000 meters = 1 kilometer (km)

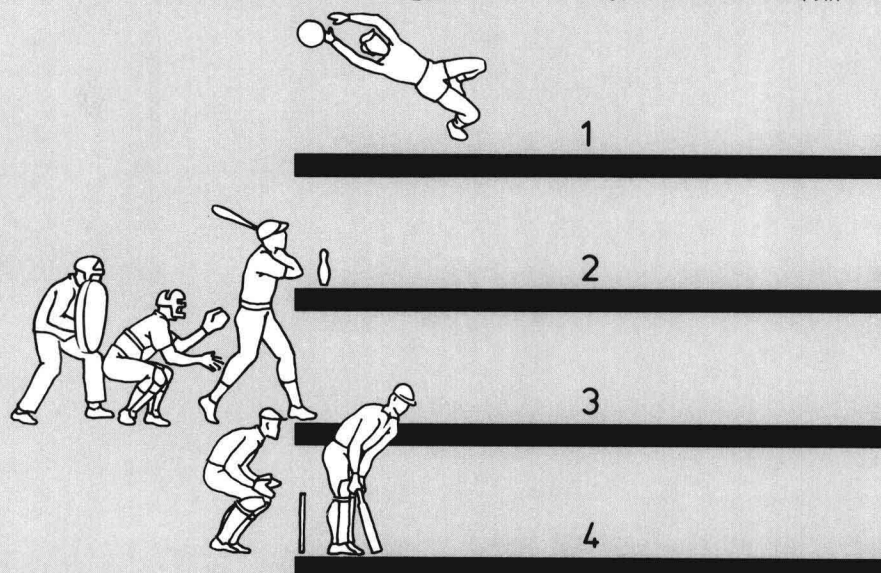
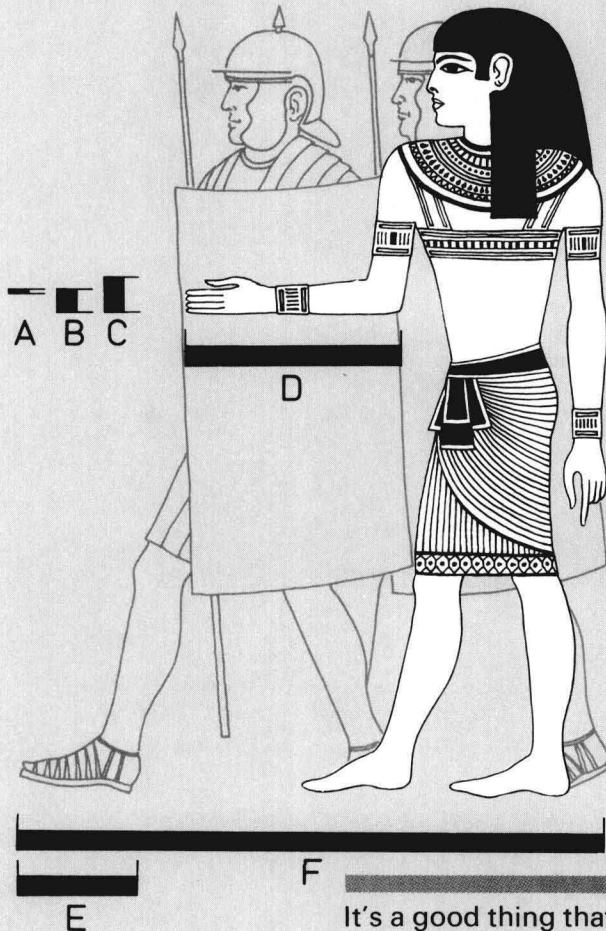
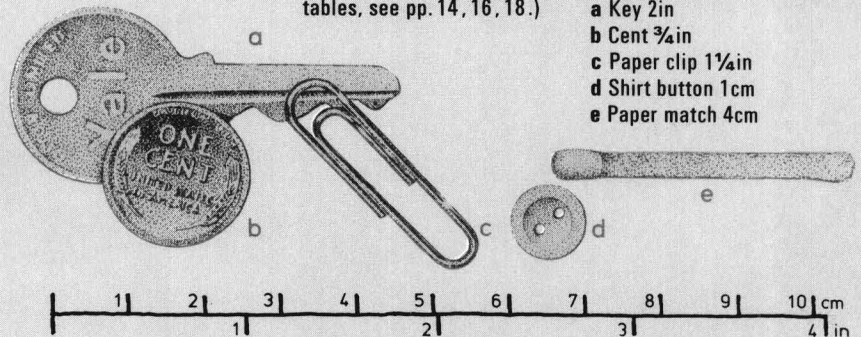
Basic units above

Included here are the most commonly used units of linear measurement, both US/imperial and metric. Given in brackets are the standard abbreviations used in this book. (For additional tables, see pp. 14, 16, 18.)

Ready measures below

These common objects can be used as convenient measures for US/imperial and metric distances. They are shown here real size together with a US/imperial and metric scale.

- a Key 2in
- b Cent $\frac{3}{4}$ in
- c Paper clip $1\frac{1}{4}$ in
- d Shirt button 1cm
- e Paper match 4cm



It's a good thing that some of our great poets of former days used the league as a unit of measurement. Imagine Tennyson's famous poem

beginning "A mile and a half, a mile and a half, a mile and a half onwards," instead of "Half a league, half a league . . ."

The ell was once widely used for measuring cloth, but lengths varied: the French ell was 54in, the English 45in and the Flemish only 27in.

12 douzièmes = 1 line
 4 lines = 1 barleycorn
 3 barleycorns = 1 inch

5½ yards = 1 rod
 4 rods = 1 chain
 10 chains = 1 furlong
 8 furlongs = 1 mile
 3 miles = 1 league

Unusual US/imperial units
left Originating in a largely agricultural society, most of the imperial units of length given in this table have now virtually died out.

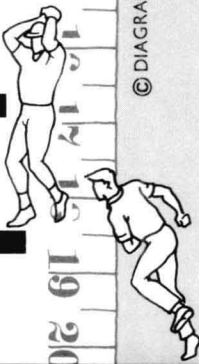
Conversion tables below
 These tables can be used to convert US/imperial distances (inches, feet, yards and miles) into metric (centimeters, meters and kilometers), and vice versa.
 For example, to convert 5in into centimeters, find

5 in the center column of the first table and then read the figure opposite it in the right-hand column (12.700cm). To find the inch equivalent of 5cm, find 5 in the center column and then read the corresponding left-hand column figure (1.9685in).

in		cm	ft		m	yd		m	mi		km
0.3937	1	2.5400	3.2808	1	0.3048	1.0936	1	0.9144	0.6214	1	1.6093
0.7874	2	5.0800	6.5617	2	0.6096	2.1872	2	1.8288	1.2427	2	3.2187
1.1811	3	7.6200	9.8425	3	0.9144	3.2808	3	2.7432	1.8641	3	4.8280
1.5748	4	10.160	13.123	4	1.2192	4.3744	4	3.6576	2.4855	4	6.4374
1.9685	5	12.700	16.404	5	1.5240	5.4680	5	4.5720	3.1069	5	8.0467
2.3622	6	15.240	19.685	6	1.8288	6.5617	6	5.4864	3.7282	6	9.6560
2.7559	7	17.780	22.966	7	2.1336	7.6553	7	6.4008	4.3496	7	11.265
3.1496	8	20.320	26.247	8	2.4384	8.7489	8	7.3152	4.9710	8	12.875
3.5433	9	22.860	29.528	9	2.7432	9.8425	9	8.2296	5.5923	9	14.484
5.9055	15	38.100	49.213	15	4.5720	16.404	15	13.716	9.3206	15	24.140
9.8425	25	63.500	82.021	25	7.6200	27.340	25	22.860	15.534	25	40.233
13.779	35	88.900	114.83	35	10.668	38.276	35	32.004	21.748	35	56.327
17.716	45	114.30	147.64	45	13.716	49.212	45	41.148	27.962	45	72.420
21.654	55	139.70	180.45	55	16.764	60.149	55	50.292	34.175	55	88.514
25.591	65	165.10	213.25	65	19.812	71.085	65	59.436	40.389	65	104.61
29.528	75	190.50	246.06	75	22.860	82.021	75	68.580	46.603	75	120.70
33.465	85	215.90	278.87	85	25.908	92.957	85	77.724	52.817	85	136.79
37.402	95	241.30	311.68	95	28.956	103.89	95	86.868	59.030	95	152.89



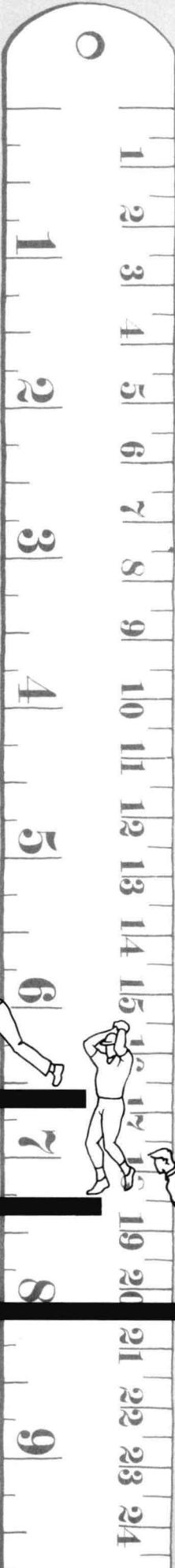
Critical distances left,
below Some examples from the world of sport:
 1 Soccer penalty spot to goal mouth center, 12yd
 2 Bowling lane, 60ft long
 3 Pitcher to batter at baseball, 60ft 6in
 4 Cricket pitch, distance between wickets, 22yd



© DIAGRAM

“Full fathom five thy father lies,” sings Ariel in Shakespeare’s *Tempest*. He meant that Ferdinand’s father had been drowned and was lying at a depth of 30ft; a fathom is a mainly nautical unit equal to 6ft.

Common rule right
 Shown real size is part of a rule with both US/imperial and metric divisions.

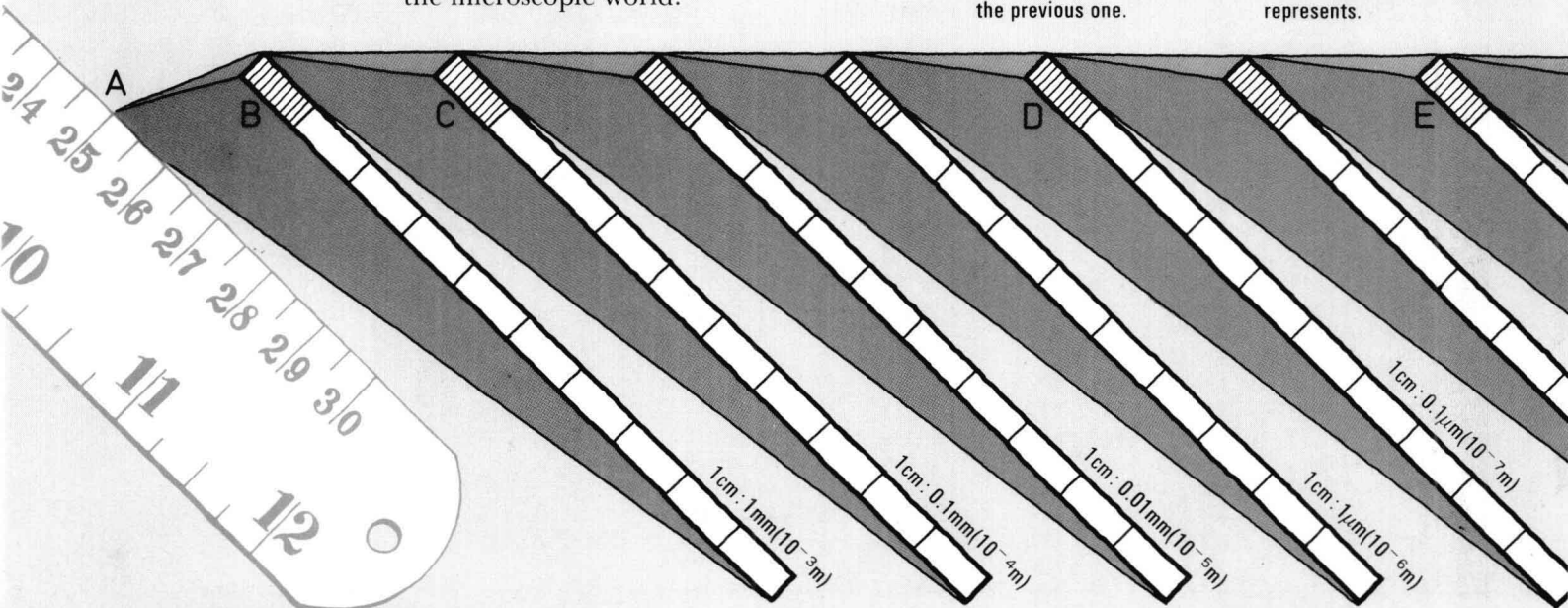


THE MICROSCOPIC WORLD

Our vision of the world is literally restricted, for with our eyes alone we can see only objects that are above a certain size. We can, for instance, see the dot above an "i" but without a microscope a single grain of most types of pollen is invisible. Here we look at measurements in the microscopic world.

Explanation of scales
below Starting with a real-size illustration of a section of a rule marked with both inches and centimeters, we have drawn a series of scales, each of which represents a 10-fold magnification of a tenth of the previous one.

Measurements here—and on other pages where we have similar scales—are expressed in metric units, since the decimal character of the metric system makes it ideal when using factors of 10. On each scale we state the distance that 1 cm represents.

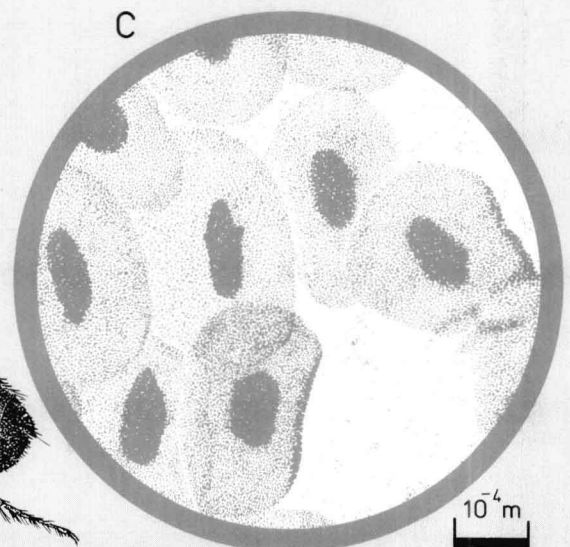
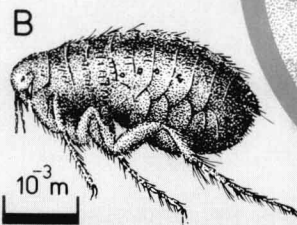


Meter	m		
Decimeter	dm	10^{-1} m	0.1 m
Centimeter	cm	10^{-2} m	0.01 m
Millimeter	mm	10^{-3} m	0.001 m
Micrometer	μ m	10^{-6} m	0.000 001 m
Nanometer	nm	10^{-9} m	0.000 000 001 m
Picometer	pm	10^{-12} m	0.000 000 000 001 m
Femtometer	fm	10^{-15} m	0.000 000 000 000 001 m
Attometer	am	10^{-18} m	0.000 000 000 000 000 001 m

Small metric units

above The table lists metric units for measuring small and microscopic distances. We start with the meter, the base unit of the International System of Units (SI), defined as 1,650,763.73 wavelengths in vacuum of the orange-red

line of the spectrum of krypton-86. This is followed by the names of smaller units, together with their abbreviations, and meter equivalents expressed first as powers of 10 and then as decimals.



An attometer, the smallest unit of linear measurement, is to a shirt button what a shirt button is to a planetary system with a diameter 8.6 times that of the solar system.

If each page in a 1000 page book were only 1 micrometer (micron) thick, then all the pages together would measure only 1 millimeter, half the thickness of the gray line below.

If magnified according to a scale where 1 centimeter represents 1 picometer (10^{-12} cm), a small raindrop (diameter 1.4 millimeters) would be as large as the Sun (diameter approximately 1,400,000 kilometers).

Distance

Small made large

bottom Each illustration has been drawn to a different one of our scales, shown by a letter. In this way we are able to see how the application of progressively larger scales brings smaller and smaller objects into view.

A The first illustration in our sequence is of a human hair, real size.

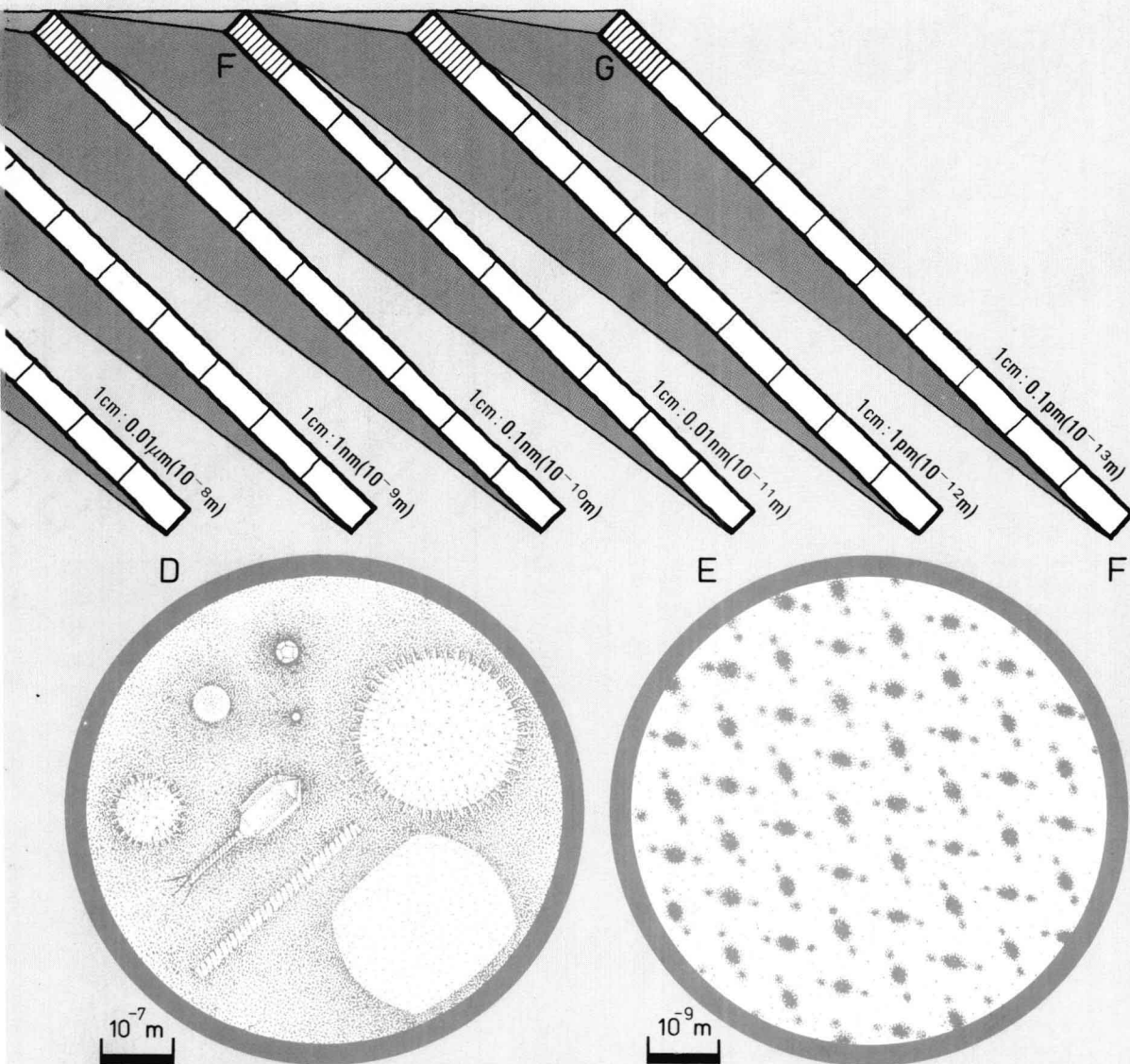
B Next we have a flea, which has been drawn to scale B, i.e. magnified 10 times. Each centimeter of our flea is equivalent to one millimeter in real life.

C The red blood cells of a frog are drawn to scale C, appearing in our illustration as they would when seen under a microscope magnifying them 100 times. Each centimeter of the enlarged image is equivalent to one tenth of a millimeter in real life.

D Next we have a selection of viruses drawn to scale D. They appear in our illustration as they would under an electron microscope magnifying them 100,000 times. Each centimeter represents one tenth of a micrometer.

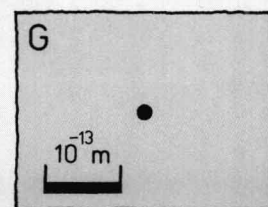
E Here we see iron atoms (large dots) and sulfur atoms (small dots) as they appear in a crystal of marcasite (iron sulphide) that has been magnified 10 million times (scale E). Each centimeter is equivalent to one nanometer.

F At the right edge of the page we show part of a sodium atom that has been drawn to scale F. This represents a magnification of 1000 million. On this scale, one centimeter of our drawing is equivalent to one hundredth of a nanometer.



If we were to draw our solar system to a scale where one femtometer of our illustration represented one centimeter in reality, it would be possible to fit more than 400 such illustrations on a single page of this book.

G The dot in the box represents the nucleus of a hydrogen atom drawn to scale G, i.e. magnified 100,000 million times. One centimeter in the box is equivalent to one tenth of a picometer.

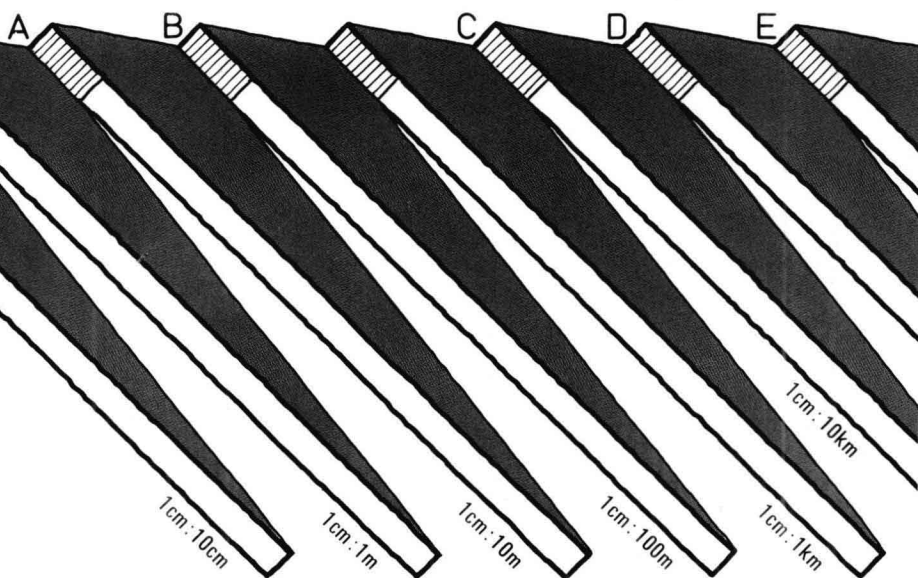
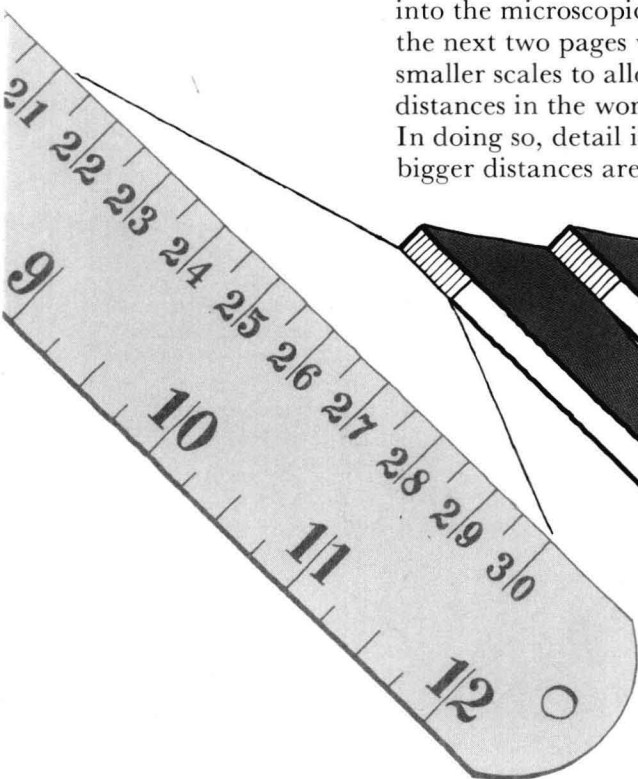


OUR WORLD AND BEYOND 1

On the preceding two pages we used progressively larger scales to look down into the microscopic world. Here and on the next two pages we use progressively smaller scales to allow us to visualize distances in the world and out into space. In doing so, detail is lost, but bigger and bigger distances are brought into view.

Explanation of scales below As on the previous two pages, we start with part of a centimeter/inch rule and then follow this with a series of scales. But here our scales become smaller, each new scale reducing the preceding scale to one tenth.

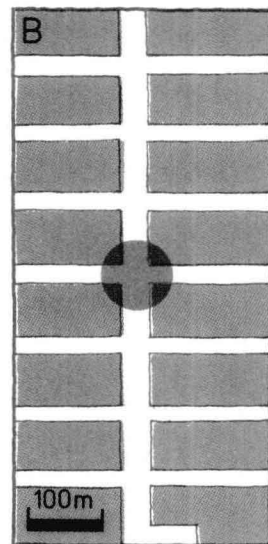
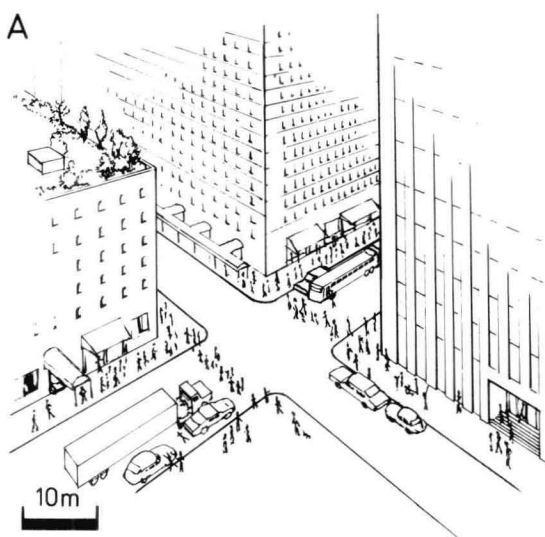
Large made small bottom Our sequence of drawings shows how by using progressively smaller scales we encompass bigger and bigger distances. **A** We start with a picture of a junction in New York, drawn to scale A where 1cm is equivalent to 10m.



Meter	m		
Dekameter	dam	10m	10m
Hectometer	hm	10 ² m	100m
Kilometer	km	10 ³ m	1000m
Myriameter	mym	10 ⁴ m	10,000m
Megameter	Mm	10 ⁶ m	1,000,000m
Gigameter	Gm	10 ⁹ m	1,000,000,000m
Terameter	Tm	10 ¹² m	1,000,000,000,000m

Large metric units above

The table begins with a meter, the base SI unit of length (see p. 14 for definition), and then gives larger units, with abbreviations, and meter equivalents given first as powers of 10 and then numerically.



The world's longest river, the Nile, would be the length of an average shoelace (66.7cm) if drawn to our scale D (1cm:100km).

If drawn to a scale where 1cm is equivalent to 10m (our scale A) this book would be no bigger than the dot on this i.