

CONTENTS

<i>Preface</i>	ix
1 Sensor and measurement	<i>page</i> 1
1.1 What is a sensor?	1
1.2 Fundamental units	7
1.3 Classification of measurement methods	11
1.3.1 Direct and indirect measurements	11
1.3.2 Absolute and relative measurements	13
1.3.3 Deflection and null methods	13
1.4 Multiple regression analysis	15
1.5 Principal component analysis	18
References	25
2 Chemical senses	26
2.1 Chemoreception	26
2.2 Biological membranes	26
2.3 From reception of taste substances to perception in the brain	29
2.4 From reception of odor substances to perception in the brain	36
References	38
3 Biomimetic membrane devices	40
3.1 Self-organization appearing far from equilibrium	40
3.2 Phase transition of artificial lipid membranes	42
3.3 Excitability: self-sustained oscillations	47
3.3.1 Five types of oscillation in the DOPH-adsorbed membrane	47
3.3.2 Observation of oscillation in a single-hole membrane	50

3.4	Theoretical explanation	52
3.4.1	Phase transition	53
3.4.2	Self-sustained oscillation	56
3.5	Effects of anesthetics and taste substances on excitability of the lipid membrane	61
3.5.1	Effect of anesthetics	61
3.5.2	Effect of bitter substances	62
3.5.3	Chaos in excitable lipid membranes	64
3.6	Effect of taste substances on static properties of membranes	66
3.7	Positively charged lipid membrane	72
3.8	Summary	74
	References	74
4	Biosensors	77
4.1	Principle of biosensors	77
4.2	Enzyme sensors	80
4.3	Microbial sensors	85
4.4	Integrated type biosensors	86
	References	90
5	Odor sensors	92
5.1	Types of odor sensor	92
5.2	Odor sensor using a quartz oscillator coated with lipid membranes	95
5.3	Metal oxide gas sensors	100
5.4	Odor sensors using conducting polymers	102
5.5	Gas-sensitive field-effect devices	104
5.6	Odor sensor using a surface acoustic wave device	106
5.7	Detection of odorants using monolayer membranes	107
	References	111
6	Taste sensors	113
6.1	Measurement of taste	113
6.2	Multichannel taste sensor	115
6.3	Response characteristics	119
6.3.1	Five basic taste qualities	119
6.3.2	Pungency and astringency	123
6.4	Taste of amino acids	125

6.4.1	Classification of taste of amino acids	125
6.4.2	Measurement of bitter taste and production of mixed taste	129
6.5	Expression of taste by basic taste qualities	134
6.5.1	Production of the taste of commercial drinks with basic taste substances	134
6.5.2	Sourness of different chemical substances	136
6.6	Mechanism of response	137
6.6.1	Responses of the negatively charged membrane to NaCl and quinine	137
6.6.2	Hybrid membranes composed of two lipid species	144
6.7	Measurement of taste of foods	148
6.7.1	Beer	149
6.7.2	Mineral water	151
6.7.3	Other water	153
6.7.4	Coffee	153
6.7.5	Milk	155
6.7.6	Tomatoes	160
6.7.7	Rice	164
6.8	Quality control of foods	165
6.8.1	Sake	165
6.8.2	Soybean paste	170
6.9	Suppression of bitterness	172
6.9.1	Suppression of bitterness by sweet substances	172
6.9.2	Suppression of bitterness by phospholipids	175
6.10	Taste-sensing field effect transistors	177
	References	178
7	Other methods to measure taste	181
7.1	Impedance measurement	181
7.1.1	Thin lipid/polymer membranes and measuring apparatus	181
7.1.2	Membrane impedance changes caused by taste substances	182
7.2	Surface plasmon resonance	187
7.2.1	Principle of SPR measurement with an LB membrane	187
7.2.2	Changes of resonance angle with taste substances	189
7.3	Surface photo-voltage method	191

7.3.1	SPV method with lipid membranes	192
7.3.2	Responses to five basic tastes	193
	References	194
8	Toward a sensor to reproduce human senses	196
8.1	Discrimination of wine flavor using taste and odor sensors	196
8.2	Perspective	204
	References	208
	<i>Index</i>	209