

Contents

Authors

Preface

Part 1 The Origin of Cell Heterogeneity in Early Development, 1

- 1.1 Introduction—Problems of Development, 3
P.F. Wareing and C.F. Graham
- 1.2 Nucleus and Cytoplasm, 5
P.F. Wareing and C.F. Graham
 - 1.2.1 Gene expression and development, 5
 - 1.2.2 Nuclear-cytoplasmic interaction in *Acetabularia* and *Blastocladia*, 6
 - 1.2.3 Embryonic development and germination, 9
 - 1.2.4 Cytoplasmic control of DNA and RNA synthesis, 10
 - 1.2.5 Cytoplasmic control of cell type, 12
 - 1.2.6 References, 13
- 1.3 The Formation of Different Cell Types in Animal Embryos, 14
C.F. Graham
 - 1.3.1 Introduction, 14
 - 1.3.2 Theories of development, 14
 - 1.3.3 Testing the theories, 14
 - 1.3.4 Experimental use of the tests, 16
 - 1.3.5 How general is the use of mosaic instructions and reference points? 25
 - 1.3.6 The origin and action of reference points in the egg, 26
 - 1.3.7 Summary and conclusions, 27
 - 1.3.8 References, 27
- 1.4 Origin of Cell Heterogeneity in Plants, 29
P.F. Wareing
 - 1.4.1 Unequal divisions in embryo development, 29
 - 1.4.2 Unequal divisions in cell differentiation, 31
 - 1.4.3 Polarity, 34
 - 1.4.4 Apical meristems of seed plants, 35
 - 1.4.5 Root apices, 37
 - 1.4.6 The self-organizing properties of apical meristems, 39
 - 1.4.7 Conclusions, 40
 - 1.4.8 References, 41

Conclusions to Part 1, 42

Part 2 Determination and Pluripotentiality, 44

- 2.1 Determination and Stability of the Differentiated State, 45
C.F. Graham and P.F. Wareing
 - 2.1.1 Introduction, 45
 - 2.1.2 Restriction of developmental potential in animals, 45
 - 2.1.3 The occurrence and stability of determination in plants, 48
 - 2.1.4 The stability of determination in animals, 51
 - 2.1.5 Conclusions, 54
 - 2.1.6 References, 54
- 2.2 The Pluripotentiality of Cell Nuclei, 55
J.B. Gurdon
 - 2.2.1 Introduction, 55
 - 2.2.2 Nuclear transplantation experiments, 55
 - 2.2.3 Molecular hybridization experiments, 61
 - 2.2.4 Conclusions, 62
 - 2.2.5 References, 62
- 2.3 Pluripotentiality of Animal Cells, 64
M.J. Evans
 - 2.3.1 Potentiality for differentiation, 64
 - 2.3.1 Teratomas, 66
 - 2.3.3 Pluripotency of teratoma stem cells, 66
 - 2.3.4 Origin of teratomas, 66
 - 2.3.5 Comparison with normal development, 67
 - 2.3.6 Establishment of *in vitro* cell lines of pluripotent cells, 68
 - 2.3.7 Experiments with cultures of pluripotent teratoma cells, 69
 - 2.3.8 Conclusions, 71
 - 2.3.9 References, 71
- 2.4 Experimental Embryogenesis—The Totipotency of Cultured Plant Cells, 73
H.E. Street
 - 2.4.1 Introduction, 73
 - 2.4.2 The egg cell and the zygote, 74
 - 2.4.3 Polyembryony, 74
 - 2.4.4 The ovule environment and the nutrition of the embryo, 75
 - 2.4.5 The role of the endosperm, 75
 - 2.4.6 The formation of embryoids in somatic tissue and cell cultures, 75
 - 2.4.7 The induction of embryogenic competence in somatic cells, 83
 - 2.4.8 The direct or indirect (via callus) formation of haploid embryoids from microspores, 84
 - 2.4.9 Embryogenic cells and the origin of polarity in the young embryo, 85
 - 2.4.10 The cleavage patterns involved in zygote, somatic and microspore embryogenesis, 87
 - 2.4.11 References, 89

Conclusions to Part 2, 90

Part 3 Cell Interactions in Development, 92

3.1 Introduction, 93

C.F. Graham and P.F. Wareing

- 3.1.1 Transfer of large macromolecules between cells, 93
- 3.1.2 Transfer of ions and small molecules between cells, 94
- 3.1.3 Release of substances by one cell which interact with the surface of another, 94
- 3.1.4 Interactions between the outsides of cells without molecular exchange, 94
- 3.1.5 Conclusions, 94
- 3.1.6 References, 95

3.2 Junctions as Channels of Direct Communication Between Cells, 96

J.D. Pitts

- 3.2.1 Introduction, 96
- 3.2.2 Detection of junctions by electron microscopy, 96
- 3.2.3 Detection of junctions by intercellular ion transfer, 98
- 3.2.4 Detection of junctions by intercellular nucleotide transfer, 99
- 3.2.5 Correlation of gap junctions, ion transfer and nucleotide transfer, 103
- 3.2.6 Lack of species specificity in junction formation, 104
- 3.2.7 Cells which do not form junctions, 105
- 3.2.8 Genetic analysis of junction formation, 105
- 3.2.9 Chemical characterization of gap junctions, 105
- 3.2.10 Nature of the cellular components which can pass through junctions, 106
- 3.2.11 The rate and extent of intercellular nucleotide transfer, 107
- 3.2.12 The formation and breakdown of junctions, 107
- 3.2.13 Junctions in developing systems, 108
- 3.2.14 References, 110

3.3 Junctions Between Plant Cells, 111

B.E. Juniper

- 3.3.1 Introduction, 111
- 3.3.2 Plant/animal analogies, 111
- 3.3.3 The ontogeny of plasmodesmata, 114
- 3.3.4 The establishment of a pattern in the distribution of plasmodesmata, 114
- 3.3.5 Structural variability, 116
- 3.3.6 Diversity in a single cell, 118
- 3.3.7 Cytomictic channels, 119
- 3.3.8 Connections between guard cells and adjacent cells in stomata, 119
- 3.3.9 Algal cell connections, 119
- 3.3.10 The creation of more complex patterns in cell-to-cell communication, 119
- 3.3.11 The functions of plasmodesmata, 120
- 3.3.12 The movement of viruses from cell to cell, 121
- 3.3.13 The transmission of electronic stimuli, 121
- 3.3.14 The control of differentiation by intercellular connections, 122
- 3.3.15 Plasmolysis experiments and the disruption of differentiation, 122
- 3.3.16 Tissue culture experiments, 122
- 3.3.17 The selective breakdown of walls or wall areas, 122
- 3.3.18 The control of genetic processes by cell communication, 123
- 3.3.19 Extending the functions of plasmodesmata, 124
- 3.3.20 References, 124

3.4 Embryonic Induction, 127

L. Saxen and J. Wartiovaara

- 3.4.1 Differentiation entails communication between cells, 127
- 3.4.2 Primary induction illustrates the problems, 127
- 3.4.3 Epithelio-mesenchymal interactions govern organogenesis, 130
- 3.4.4 Inductive communication is achieved in different ways, 132
- 3.4.5 Molecular mechanisms of induction are still unknown, 137
- 3.4.6 References, 139

3.5 Cell Recognition and Pattern Formation in Plants, 141

R.B. Knox

- 3.5.1 Introduction, 141
- 3.5.2 Gametic communicators: the pollen-wall proteins, 142
- 3.5.3 Plant lectins: somatic cell communicators? 155
- 3.5.4 Wall pattern formation in cell differentiation, 160
- 3.5.5 Conclusions, 166
- 3.5.6 References, 166

3.6 Pattern Formation in Animal Embryos, 169

T. Horder

- 3.6.1 Introduction, 169
- 3.6.2 The positional information model, 174
- 3.6.3 Embryonic induction, 175
- 3.6.4 Positional information or embryonic induction? 186
- 3.6.5 On the genetic control of development—homeotic mutations, 188
- 3.6.6 A second look at embryonic induction, 190
- 3.6.7 Summary and conclusion—The cell recognition model, 192
- 3.6.8 References, 195

Conclusions to Part 3, 197

Part 4 Hormonal Control of Development, 199

4.1 Introduction, 201

C.F. Graham and P.F. Wareing

- 4.1.1 Long-range interactions, 201
- 4.1.2 Hormones as cell type determinants, 201
- 4.1.3 Hormones as inducers of differentiation, 201
- 4.1.4 Hormones as co-ordinators within the organism as a whole, 202
- 4.1.5 References, 203

4.2 Signalling Systems in Dictyostelium, 204

J.T. Bonner

- 4.2.1 Introduction, 204
- 4.2.2 Evidence for different signals, 205
- 4.2.3 The biochemistry of signalling, 212
- 4.2.4 Conclusions, 214
- 4.2.5 References, 215

4.3 Hormones and Differentiation in Plants, 216

M.A. Hall

- 4.3.1 Introduction, 216
- 4.3.2 Root and shoot initiation, 216
- 4.3.3 Induction of vascular tissue, 219
- 4.3.4 Induction of secondary thickening, 224

4.3 *continued*

- 4.3.5 Mobilization of reserves in cereal endosperm, 224
- 4.3.6 Stem and coleoptile extension, 228
- 4.3.7 Conclusions, 229
- 4.3.8 References, 230

4.4 The Hormonal Control of Amphibian Metamorphosis, 232

K. Beckingham-Smith and J.R. Tata

- 4.4.1 Introduction, 232
- 4.4.2 The action of thyroid hormone in metamorphosis, 235
- 4.4.3 References, 244

Conclusions to Part 4, 246

Part 5 The Molecular Biology of Development, 248

5.1 Self-Assembly, 249

A. Miller

- 5.1.1 Introduction, 249
- 5.1.2 Molecular folding, 250
- 5.1.3 Molecular aggregation—(1) Like molecules, 254
- 5.1.4 Molecular aggregation—(2) Unlike molecules, 261
- 5.1.5 Conclusions, 267
- 5.1.6 References, 268

5.2 Organelle Development, 270

I.W. Craig and B.E.S. Gunning

- 5.2.1 The structure and function of chloroplasts and mitochondria, 270
- 5.2.2 Development and biogenesis of chloroplasts, 280
- 5.2.3 Development and biogenesis of mitochondria, 289
- 5.2.4 Division of organelles, 295
- 5.2.5 The problems raised by the presence of multiple copies of organelle DNA, 296
- 5.2.6 Conclusions, 297
- 5.2.7 References, 298

5.3 Control of Gene Expression during Differentiation and Development, 302

P.J. Ford

- 5.3.1 Introduction, 302
- 5.3.2 Theories of differentiation, 302
- 5.3.3 Genetic organization in eukaryotes, 303
- 5.3.4 Transcription, 315
- 5.3.5 The products of transcription, 317
- 5.3.6 The control of RNA synthesis in development, 321
- 5.3.7 Translation, 333
- 5.3.8 Cytoplasmic factors important in controlling gene activity in development, 335
- 5.3.9 Nuclear proteins, 338
- 5.3.10 Conclusions, 338
- 5.3.11 References, 339

Conclusions to Part 5, 345

Part 6 Environmental Control of Development, 348

6.1 Environmental Control of Development, 349

P.F. Wareing

- 6.1.1 Introduction, 349
- 6.1.2 Photoperiodic control of flowering, 349
- 6.1.3 Photoperiodism and reproduction in animals, 351
- 6.1.4 Environmental control of dormancy and diapause, 351
- 6.1.5 References, 352

6.2 External Factors Controlling Development: The Photocontrol of Plant Development, 353

H. Smith

- 6.2.1 The plasticity of plant development, 353
- 6.2.2 The phenomenology of the photocontrol of plant development, 353
- 6.2.3 The photomorphogenic response systems, 355
- 6.2.4 Structure and properties of phytochrome, 361
- 6.2.5 The primary action of phytochrome, 366
- 6.2.6 Molecular mechanisms of developmental control, 374
- 6.2.7 The role of phytochrome in the natural environment, 377
- 6.2.8 References, 379

Conclusions to Part 6, 381

Index, 383