CARINI AND OWENS'

Neurological and neurosurgical nursing

BARBARA LANG CONWAY-RUTKOWSKI

Eighth edition

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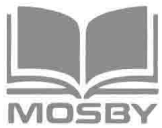

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CARINI AND OWENS'

Neurological and neurosurgical nursing

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To my loving family:

Mom and **Dad,** who inspired me to persevere

Art, who gives me encouragement and support while sharing life's pleasures along the way

Laura, Michele, and **Cheryl,** the best children that a mother could have

Granny, whose positive attitude and humor is an inspiration to all who know her

PREFACE

The eighth edition of *Carini and Owen's Neurological and Neurosurgical Nursing* has been totally revised to include the changes that users have been requesting. Two of the most apparent changes are the reorganization of material to include more information on assessment and nursing intervention and the movement away from the medical model to a nursing model.

Neurological and neurosurgical nursing can be very challenging to teach to undergraduate students, since it encompasses such a wide variety of technical points in pathophysiology, intervention possibilities, and skills in contemporary nursing.

To make things fall into a pattern, I have begun the book with a part entitled Foundations of Neurology. The embryology facilitates better understanding of errors in formation resulting in pathophysiology. The material on anatomy and physiology has been thoroughly reorganized to facilitate the learning of normal neurophysiology. Information presented on neurotransmitters is helpful in understanding new research findings that link them with pharmacology and the neurochemistry of body functions.

Part two, Factors Affecting Neurological Outcomes, comprises seven chapters that greatly influence nursing assessment and intervention in clients with neurological problems, as described below.

Development of Perception, Integration, and Response, Chapter 5, provides the practitioner with a comprehensive environmental context of factors that underlie client performance. This chapter is particularly valuable in testing children because it gives the nurse insight into the development of performance parameters in neurological assessment.

Sexuality is considered the essence of the client's total person and as such is incorporated into the total nursing process.

In the chapter entitled Cognitive and Behavioral Impairments, approaches are suggested for working with various types of client behavior. The portion on developmental delays is totally new and incorporates important changes in living arrangements, family involvement, and potentials for nursing intervention in the intellectually impaired.

Chapter 8, Adaptive Problems in School and Learning, provides a comprehensive background on various approaches to diagnosis and remediation in learning disabilities. The reader not only learns the vocabulary essential to dealing with this common childhood problem, but also acquires the knowledge essential to nursing involvement in assessment and intervention.

In the chapter on pain, the major theories and viewpoints are detailed along with assessment, current interventions, and the neurochemical findings affecting the pain experience and pain treatment.

Impaired Consciousness, Chapter 9, includes the points in differential assessment so vital to prehospital nursing, the term used to describe care provided at the scene and in transit to the hospital. Global ischemia is reviewed in relation to barbiturates. The Glasgow Coma Scale is identified as a method for standardizing a "thumbnail" sketch on general client status. Total management for the client is also a part of the chapter.

Part three, Assessment, is composed of two chapters that detail current techniques, tests, and

diagnostic studies essential to evaluate everyone across the life-span.

Part four, Disorders Affecting Functional Capacities, includes two chapters. Chapter 13, Static and Developmental Lesions, is organized in relation to Part one, Foundations of Neurology, so that disorders are discussed within a framework. Sections of nursing assessment and intervention are greatly expanded for the child with cerebral palsy and the myelodysplastic child. Chapter 14 presents a comprehensive approach to seizures, as categorized into the international classification, and to headaches—a type of pain for which nursing assessment and intervention are key ingredients to successful treatment.

Part five, Disorders Affecting Input, Integration, and Output, is a new collection of material. In giving workshops I have found that many nurses have difficulty in systematically relating disorders to interruptions in physiological functions. So I organized this section to provide a logical framework for understanding neuropathophysiology. Chapter 15 gives you everything necessary, when combined with Chapter 11, to evaluate a sensory, motor, or combined sensorimotor problem. The next four chapters divide problems into disorders arising from changes in sensibility, nutrition, and metabolism; disorders affecting motor outcomes; disorders of refined movements; and disorders arising from cranial nerves. Chapter 16 through 19 provide current comprehensive assessment and management of all major disorders in these categories, along with expected outcomes for most conditions.

Part six, Invasive Disorders, concerns the care of clients with infections and space-occupying lesions affecting the nervous system.

I am proud of Part seven, Disorders Related to Extraneurological Processes, because it includes the kind of information that prehospital and emergency room nurses need to assess clients and intervene successfully in neurological trauma. The importance of cardiopulmonary-cerebral resuscitation (CPCR) is emphasized here, as it is in coma. Another area of emphasis is hypertension, since nurses may play such an important role in prevention of severe pathophysiological outcomes associated with poorly controlled high blood pressure. Stroke is discussed in relation to the management the client and family require in both acute and long-term phases of care.

Part eight, Assistive Intervention, includes rehabilitation, surgical techniques and nursing intervention, adjunctive interventions, and medications in common use. The appendix details helpful audiovisual aids.

This book will be helpful to you both as a reference and as a means for instruction of undergraduate students in basic and advanced care of the neurological client throughout the life-span.

Special thanks goes to my parents, Lt. Col. Donald R. and Hilda M. Lang for giving me the opportunity to be where I am today; to my husband, Arthur D. Rutkowski, for his constant loving support and encouragement; to my children, Laura, Michele, and Cheryl, for their love and help; to Edna Lang, who spent a lifetime helping others; and to Granny Rathke, a shining light to many people who have weathered life's storms.

Thank you June Willis, Marjorie Pfaudler, Joyce Dungan, Becky Smith, and Susan Nunchuck for your assistance. I also appreciate the editorial assistance of Diana King.

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Barbara Lang Conway-Rutkowski

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PART ONE

FOUNDATIONS OF NEUROLOGY

1

EMBRYOLOGY

The growth processes that characterize the formative period have far-reaching effects on the integrity and functional operations of the nervous system throughout the life cycle. Thus an understanding of neural biodynamics necessarily begins with an overview of development.

Developmental embryology is the study of the period between conception and birth, whereas developmental anatomy encompasses the entire developmental process. For the purposes of this book, let us attend to developmental embryology as a means of better understanding developmental anatomy.

MORPHOGENESIS

The process of morphogenesis includes the fundamental components of growth, differentiation, and relative movement. In this context *growth* refers to increased size and mass resulting from protoplasmic and extracellular material synthesis rather than to the usual definition of growth as resulting from the ingestion of foodstuffs or fluids. Tissue growth is further differentiated as multiplicative, auxetic, or accretionary growth or some combination of these patterns.

Multiplicative growth takes place as the mitotic division of cells occurs in the zygote. It may occur once, as in the case of oocytes and neurons, or in a repetitive manner, as in the instance of epidermis and intestinal epithelium, where cellular death and regeneration are parts of a constant process. Research continues to define the precise mechanism responsible for the regulation, production, and cessation of multiplicative tissue growth.

Some general components influencing this process include genetic factors; nutritional factors; the primary organizer region; and other endocrine, thermal, photic, and mechanical determinants. Specific cell growth related to particular tissue needs and operations is probably regulated by chalones, inhibitory secretions produced by the tissue itself to regulate the mitotic cellular division.

Auxetic growth is the deoxyribonucleic acid (DNA)–controlled increase in cellular size. DNA present in each diploid nucleus of a cell determines the production capacities for the replacement of protein, which breaks down throughout the life cycle of the cell. Auxetic growth ceases when the cell reaches its maximum capacity to produce. Variations in growth patterns of the several cell types occur. In certain cells the nucleus divides to provide the opportunity for further growth when the limits of auxetic growth within one cell have been attained. In the granule cells of the cerebellar cortex this ongoing multiplicative growth results in a decreased cell volume in individual cells. In other cells the single diploid nucleus is aided by surrounding glial cells, which act as a functional unit with the neuron to provide additional metabolic and nuclear materials for growth. In this instance neurons may expand to a large size.

Accretionary growth refers to an increase in the quantity of structural intercellular material in a given tissue. Outcomes of this process include fibrous connective tissue, bone, tendon, joint capsule, cartilage, and cornea.

During the process of embryonic growth all these growth patterns—multiplicative, auxetic, and accretionary—are combined in cellular differentiation. The exact combination of these patterns depends on the specific form, size, function, age, and regenerative patterns characteristic of that

body part. Cellular death and removal are integral parts of all phases of development from embryonic life on. Through the process of death and removal of cellular components, tissue balance is maintained, and progression from rudimentary forms of growth to maturation is allowed.

Cellular differentiation

The quest for understanding the processes that influence cells to combine into functioning tissue continues. The contemporary theory that explains cellular differentiation combines two earlier positions, namely, preformation and epigenesis. *Preformation* refers to the belief that all body parts are present in minute form in the zygote, so that growth merely implies an increase in size and development until maturity is attained. *Epigenesis* is a theory that describes organ development as the growth of new formations. The contemporary definition combines these theories and views the cytoplasmic informational content and nuclear genetic mechanisms as the "preformation" that is responsible for the growth and development, or "epigenesis," of new body structures in the zygote (Strickberger, 1976).

Cellular differentiation is further explained in relation to protein and control complexes. Protein is the catalyst that comprises the many enzymes involved in forming the sequence of energetic and structural changes fundamental to the life process. Control complexes that regulate this elaborate process of protein synthesis include primary organization, genetic control, and an intricate system of chemical messengers that relay information within and among cells.

Primary organization. Two types of tissues are evident in primary organization: inductive (or self-differentiating) tissue and dependent tissue. Some tissue has an early predisposition for self-differentiation and displays an early fate. Other surrounding tissue is pluripotent, which means that it has the ability to become several different tissues in response to the specific growth of adjacent inductive tissue during the initial stages of growth.

The dorsal blastophore region exhibits powerful inductive influences on surrounding tissue and is referred to as the primary organizer region. Growth in the dorsal blastophore region results in the development of the embryonic avis and its adjacent tissue. As the organization of sequential chordate development occurs, other subordinate organizing regions become apparent.

Communication between these inductive and dependent tissues is believed to occur through undefined intracellular and intercellular chemical messengers.

Genetic influences. Genetic influences are the second form of powerful control that modifies cellular differentiation. Although we still understand these genetic influences only on a theoretical basis, a brief review of current thoughts on this mechanism is warranted.

The chromosome, a double strand of DNA in each cell nucleus, contains the genetic codes. This DNA comprises amino acid configurations that differ in the various genes. These genes, which are attached to each other, regulate enzyme synthesis and ultimate body metabolism through their control of ribonucleic acid (RNA).

Chemical messengers. The mechanism by which the foregoing elaborate, complex processes operate involves chemical messengers. DNA loci, found in functional groups called *operons,* comprise structural genes, a regulator gene, and an operant segment. The structural genes specify the polypeptides, which are the simple amino acid molecules that form either structural or enzymatic proteins. The production or inactivation of these structural genes depends on whether the operant segment is free to function or is inhibited by a repressor protein produced by its neighboring regulator gene (Fig. 1-1).

Repressor protein production from the regulator gene is controlled by chemical substances from the blastomeres and the embryonic inducers, which are discussed with the regional organizers as described under primary organization. Chalones are the substances in the local tissues that play an important role in growth processes, since they function as repressors to balance the circulating hormones and the local tissue cell genomes.

Therefore sequential growth and cellular differentiation should be viewed as an orderly process dependent on a balanced, specified pattern of operation and on inhibition of operons through the regulation of chemical interactions of inducers, circulating hormones, repressors, corepressors, and local tissue chalones. Extrachromosomal nucleic

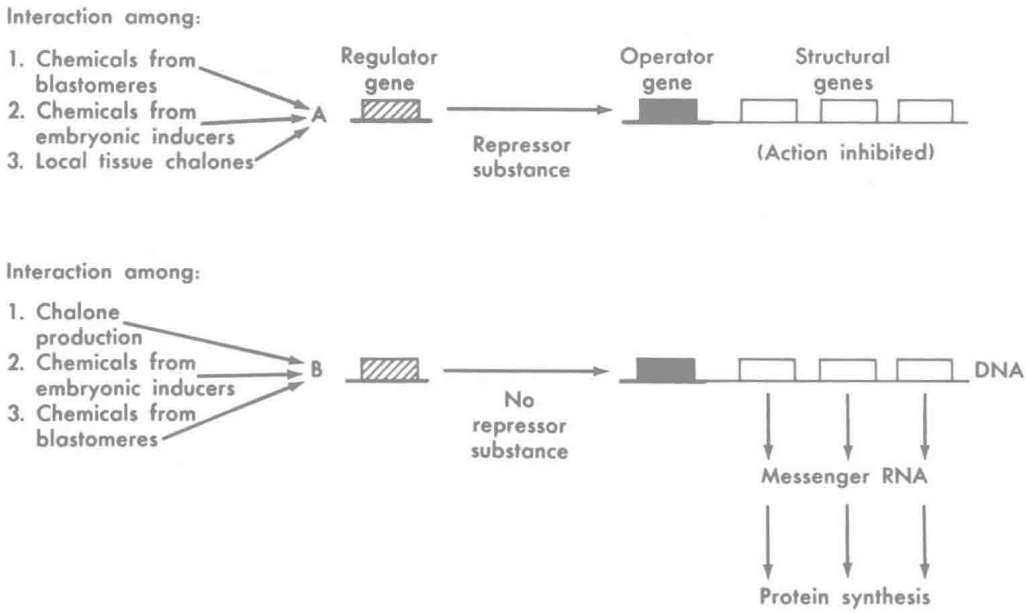

FIG. 1-1. Interactions among regulator, operant, and structural genes. (From Conway, B.L.: Pediatric neurologic nursing, St. Louis, 1977, The C.V. Mosby Co.)

acids may also play a role in this process, though that role is as yet undefined.

Relative movement. The selective interactions on tangential cellular surfaces are referred to as relative movement. Through this process, changes in the peripheral form occur so that groups of cells become sheets, balls, masses, and tubes and invaginate to make continuing embryonic development possible. Another related growth process is *contact guidance*. Some familiar examples of contact guidance are the regeneration of nerves on Schwann cell surfaces and the growth of new nerve fibers on the pathways of previous nerve fibers.

Hereditary factors. Factors of inheritance are key determinants of the eventual phenotype, characteristic traits in each individual, that each human possesses. Principles of inheritance are reviewed in this section, and untoward outcomes of errors during the process of embryogenesis are detailed in various portions of this text.

Meiosis and gametogenesis are the initial stages of growth. In the female 6 million primary oocytes are produced in the ovary, but only about 400 are capable of fertilization during the reproductive years. Initially these oocytes undergo the first meiotic division prenatally; this division is complete before ovulation. Then each oocyte remains dormant until ovulation, when it matures in conjunction with the ovarian follicle. Ovulation signals the beginning of the second meiotic division, which is complete by the time fertilization occurs. After the last division, one mature ovum contains 23 chromosomes and the bulk of cytoplasm, and smaller daughter cells are unable to reproduce.

Sexual maturity is attained in the male before the process of spermatogenesis occurs within the seminiferous tubules of the testes. The first and second meiotic divisions occur within 75 days. At the completion of spermatogenesis, four mature sperm cells are apparent; these have the ability to move about independently. Each mature sperm cell contains 23 chromosomes.

During the process of fertilization, the spermatozoon penetrates the ovum. The head and neck stay within the ovum, whereas the midsection and tail become detached and discarded. The head swells into a pronucleus that moves toward the center of the ovum to unite with the female pronucleus. Both nuclei duplicate their DNA material.

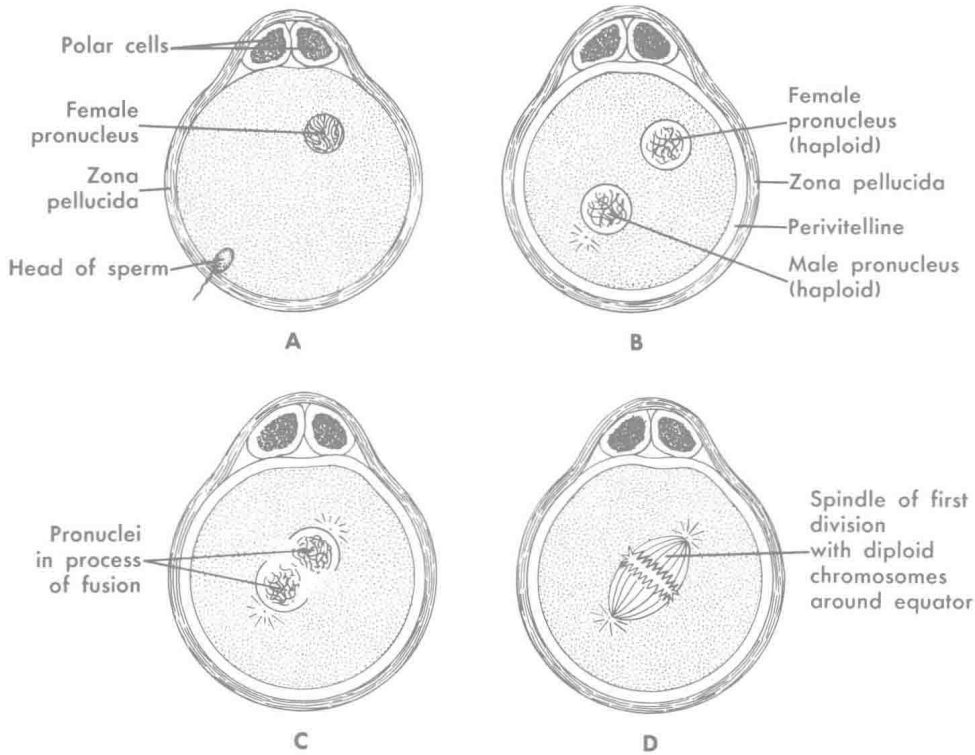

FIG. 1-2. Process of fertilization. **A,** Sperm penetrates ovum. **B,** Pronuclei gravitate toward center of ovum. **C,** Pronuclei fuse. **D,** Appearance of two centrioles and alignment of chromosomes around equator.

Soon two centrioles are apparent (Fig. 1-2), and the chromosomes of the pronuclei align themselves on the spindle between the centrioles, where they exchange material between the two sets of 23 chromosomes. The nuclei split longitudinally, and the two sets migrate to opposite poles of the cell. A deepening groove becomes evident on the cell as the zygote progresses to the stage of cleavage or segmentation.

Inheritance is further determined by the genes in the chromosomes of all somatic cells. Each corresponding gene (allele) has a specific location on its chromosome. It is through the genes that traits from the ovum and spermatozoon are transmitted to future generations.

During fertilization each parent contributes 22 autosomes and 1 sex chromosome. Although males may provide either an X or a Y chromosome, females supply only the X chromosome. A male offspring results when the Y chromosome unites with an X chromosome, whereas a female results when two X chromosomes combine. The determination of sex in the offspring occurs when the pronuclei combine in the fertilized ovum.

Interactions of the structural and regulator genes influence cell morphology at the molecular level. The genetic traits (genotype) of an individual then become the physical characteristics of that individual (phenotype) at a more general level. The expression of an individual genotype depends on the likeness or difference of the two alleles at corresponding points in two homologous chromosomes. When one allele represents a dominant trait and one a recessive trait, the individual is heterozygous for the trait. If both alleles represent either a dominant or a recessive trait, the individual is homozygous for the trait.

The dominant trait in heterozygous individuals is expressed, whereas the recessive trait is not expressed. In the instance of homozygous expres-

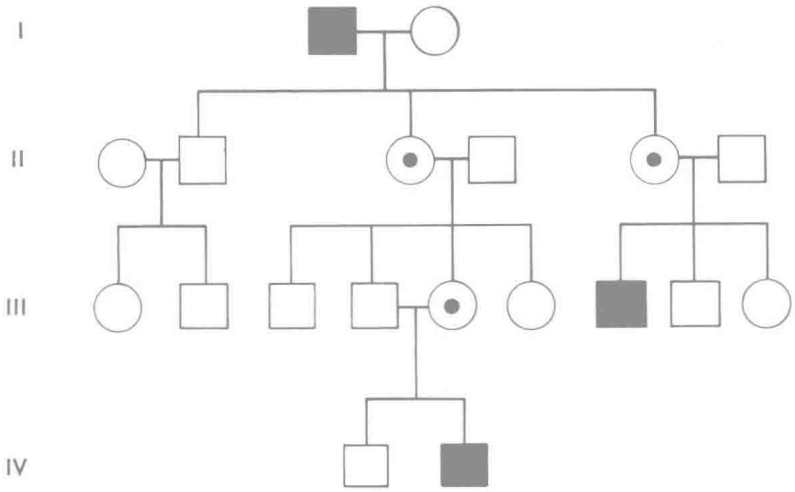

FIG. 1-3. Pedigree showing typical sex-linked recessive inheritance. *Dot within circle,* Females who are carriers; *black squares,* males who are affected. (From Chinn, P.L.: Child health maintenance: concepts in family-centered care, St. Louis, 1974, The C.V. Mosby Co.)

sion, both alleles carry the same trait, and expression may be either recessive or dominant, accordingly. Clinically it is difficult to distinguish a heterozygous-dominant from a homozygous-dominant trait.

Genetic linkage has a decided effect on phenotypes of individuals. Because of genetic linkage, traits from genes in proximity on the same chromosomes tend to be inherited together. Although investigation of disease-associated traits is in the initial stages, preliminary information is available. One instance of this phenomenon is apparent in sex-linked patterns of inheritance, such as that seen in hemophilia. Hemophilia, most commonly seen in males, is transmitted by females, who must be heterozygous for the trait. If a hemophiliac male mates with a female homozygous for the trait (normal), the male offspring will not have the disease, but all the female offspring will be heterozygous for the trait. Thus the disease will skip one generation and be expressed in half the male offspring produced by the affected (heterozygous) females (Fig. 1-3).

Variable expressivity is the phenomenon that explains why some persons inherit a trait in a differing degree from others with the same genotype. The explanation for the differences in phenotypes in individuals with the same genotypes is poorly understood.

Critical periods of development

The chief components of the central nervous system are as follows:

White matter	Gray matter
Axonal bundles	Cell bodies
Glial cells	Dendrites
Blood vessels	Axons (unmyelinated)
Limited extracellular matrix in contrast to other body tissue	Limited extracellular matrix in contrast to other body tissue

These structures are susceptible to injury at various periods in neural development. In reality, a rigid timetable or an exact definition of a causative agent is not practical at this point in scientific understanding, since many defects are believed to result from the interaction of various factors. Although the causative mechanism is not clearly designated as purely environmental or inherited, resulting conditions are often described separately.

Environmental influences. When environmental interferences interrupt the development of the zygote during the first 2 weeks, implantation of the blastocyst is often incomplete, and spontaneous