FOSTERING COGNITIVE INTEGRATION & UNPACKING EXPERTISE:

THE **NEED** FOR **INTEGRATED ILLNESS SCRIPTS**

IN MEDICAL & HEALTH PROFESSIONS EDUCATION

AQUIFER SCIENCES

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Integrated Illness Scripts provide **a new integrated mental model** for linking clinical medicine and basic science causal mechanisms to **improve clinical decision-making.**

INTRODUCTION

Aquifer's Integrated Illness Scripts—developed by teams of expert basic science and clinician educators from around the country—provide a new mental model for advancing cognitive integration in learners and unpacking encapsulated expertise from faculty. This new framework enhances the traditional illness script format by interweaving basic science and clinical knowledge in a format designed to enable more effective and efficient clinical decision-making.

The Integrated Illness Scripts are the primary integration tool of the Aquifer Sciences Initiative, a partnership between Aquifer and IAMSE (International Association of Medical Science Educators) to develop resources that promote cognitive integration and collaborative teaching of basic and clinical sciences in health professions education. The Integrated Illness Scripts put the goals of the Initiative into practice, providing an evidence-based pedagogical structure and effective learning materials for both classroom and clinical settings.

GOAL:

Educate students to make **better, safer clinical decisions** supported by **sound biomedical reasoning.**

COGNITIVE INTEGRATION

Cognitive integration is a process that occurs in the minds of learners and experts as they interweave relevant basic science and clinical knowledge when reasoning through a patient problem.

Clinicians must constantly integrate diverse information as they see patients—recalling, transferring, learning, and applying medical knowledge and science concepts in order to make effective clinical decisions and to expand expertise. Ultimately, cognitive integration also includes the comprehensive integration of basic, social, behavioral and health systems sciences with clinical practice.

Why Does Cognitive Integration Matter?

The AAMC and Howard Hughes Medical Institute recognized the central importance of cognitive integration in medical training and practice in their 2009 report "Scientific Foundations for Future Physicians." The report states that "The desired outcome of the medical education process should be scientifically inquisitive and compassionate physicians who have the motivation, tools, and knowledge to find the necessary information to provide the best and most scientifically sound care for their patients. As such, **the medical school curriculum should be integrated across disciplines and repeatedly emphasize the importance and relevance of the sciences basic to medicine. Physicians should possess a deep understanding of the fundamental biomedical scientific principles needed to deal with the unexpected;** they should not rely solely on algorithm-based practice." [3]

Research shows that the **effective cognitive integration** of basic and clinical science **improves diagnostic accuracy**, particularly in novice clinicians.

In their landmark study [1], Baghdady et. al provided dental students with learning resources that either integrated or segregated diagnostic radiology concepts and biomedical knowledge. When provided with new clinical problems, students who received the integrated materials outperformed those who received the segregated materials in both immediate and delayed scenarios. The researchers concluded that "**teaching basic sciences integrated with clinical features produces higher diagnostic accuracy in novices** than teaching basic sciences segregated from clinical features."

Unfortunately, research also demonstrates that **learners seldom make the correct connections** between biomedical knowledge and clinical features when left to their own devices. [1, 2]

BUILDING INTEGRATED ILLNESS SCRIPTS

Traditional Illness Scripts

The term 'illness script' describes the mental model clinicians use to organize, store, and retrieve information on a specific clinical problem (disease, condition, or syndrome).[4] Clinicians' illness scripts grow with experience, and typically include a mental composite of the predisposing conditions, the pathophysiological insult, and predominant clinical symptoms. Experienced clinicians draw continuously from their cognitive library of illness scripts to make clinical decisions on testing, diagnosis, and management.

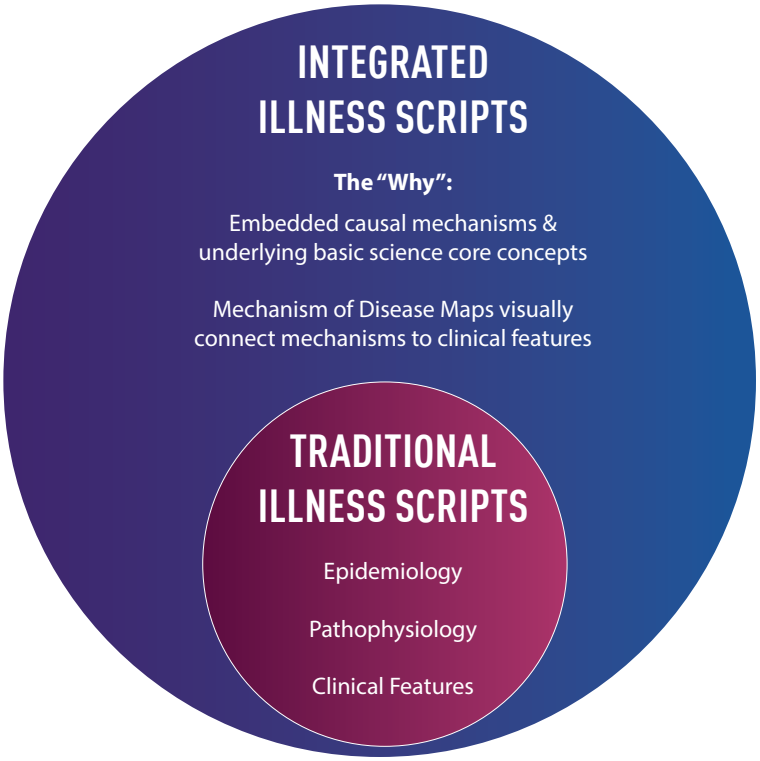
Research demonstrates that the way a clinician encapsulates relevant information within an illness script directly impacts his or her ability to retrieve information during clinical decision-making.[4] Although traditional illness scripts incorporate the key clinical components, **the traditional model lacks effective direct connections between the symptoms and the underlying core basic science concepts critical to understanding the "why" behind their occurrence.** Without clear cognitive connections to the causal mechanisms, clinicians do not effectively encapsulate the complete picture needed for robust long-term recall and deeper understanding.

What are Integrated Illness Scripts?

Building on the traditional illness script format, **Aquifer's Integrated Illness Scripts add embedded basic science core concepts and causal mechanisms** within each clinical feature, and display the connections visually through Mechanism of Disease Maps.

Integrated Illness Scripts were born as a result of a highly collaborative effort between teams of basic science and clinical educators as part of the Aquifer Sciences Initiative. After the successful completion of a nationally-developed sciences curriculum, captured in the Aquifer Sciences Curriculum Database (see pg. 7), the Aquifer Sciences team turned their attention to developing teaching and learning tools.

Aquifer's Integrated Illness Scripts provide a truly integrated mental model that explicitly translates the theory of cognitive integration into a tangible framework for teaching, learning, and clinical application. These learning tools were developed to support students through all phases of their undergraduate medical or health professions education, to be used in the classroom or patient care settings.



ADDRESSING TEACHING & LEARNING CHALLENGES

Integrated Illness Scripts (IIS) address the challenges of:

Helping novice clinicians make the correct connections between biomedical knowledge and clinical features by directly interweaving the information, fostering a deeper understanding of the "why" behind medical conditions.

Supporting faculty in 'unpacking' their own deeply interconnected, encapsulated knowledge to share with students and faculty collaborators in other basic science and clinical disciplines.

Embedding Basic Science to Drive Cognitive Integration

Aquifer Integrated Illness Scripts embed clear and concise basic science explanations and underlying core concepts into the overview, epidemiology, and clinical features sections of the IIS to foster a deep understanding of why each condition occurs (see pg. 8-9). An accompanying Mechanism of Disease Map (see pg. 10) provides a visualization that guides the learner from the initial insult through each causal mechanism to explain the resulting clinical features.

The practice of applying Integrated Illness Scripts to patients and case scenarios strengthens the cognitive integration process and clinical reasoning framework for each clinical condition in the minds of learners. **By connecting the mechanistic backstory of each clinical feature for a disease or condition, learners can more effectively select and justify testing and treatment decisions.**

Unpacking Encapsulated Knowledge

Clinicians constantly pull from a repertoire of traditional illness scripts to make patient care decisions. The more experienced the clinician, the more deeply encapsulated this information becomes over time. This tacit and almost instinctive knowledge is critically important to enable expertise and daily practice, but it makes unpacking this information to share with novice clinicians very difficult. [4] The same phenomenon exists for basic scientists—encapsulation confounds the ability to unpack deeply-seated biomedical knowledge in an area of discipline-based expertise.

As learners absorb the linked information in Integrated Illness Scripts, they form connections between the basic science causal mechanisms and clinical findings that will become part of their own expertise. By exposing and integrating this deep and comprehensive knowledge, learners are able to encapsulate for themselves a more complete understanding of conditions and diseases for future recall.

For faculty, Integrated Illness Scripts make complete, interdisciplinary knowledge for a given condition easy to reference and explain, allowing clinical educators to reference the basic science concepts learned long ago. Basic scientist faculty can more easily add clinical relevance and expanded basic science information outside of their own discipline to their teaching without additional faculty time.

Nationally Developed by Teams of Educators

To develop Aquifer's Integrated Illness Script model, deep collaboration between basic science and medical educators was required. The Aquifer Sciences Integrated Illness Scripts were created through a national, multi-institution authoring project, overseen by the Aquifer Sciences Leadership Team. Following a national call for participation, teams from six medical schools were selected to draft Integrated Illness Scripts on common conditions seen in core rotations. [5] Teams at each institution included clinician educators, basic science faculty, and medical students.

Following the completion of the authoring process, each script underwent an extensive peer review process that included subject experts from the Aquifer Sciences Leadership Team and the:

- Aquifer Sciences Curriculum Editorial Board (11 basic science faculty members, each representing a different discipline)
- Aquifer Sciences Clinical Education Consultants (9 interdisciplinary clinical faculty members)

Aquifer's Integrated Illness Scripts will be reviewed and updated on a regular basis by these teams of clinical and basic science faculty.

AQUIFER SCIENCES LEADERSHIP TEAM

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ABOUT THE AQUIFER SCIENCES CURRICULUM

The Aquifer Sciences Curriculum is the first nationally-developed and publicly available curriculum that comprehensively outlines the 10 most important core concepts in each basic science discipline that must be understood by health professions learners in order to provide safe, routine patient care.

The Aquifer Sciences Curriculum was developed by over 100 leading basic science and clinical educators from across the US.

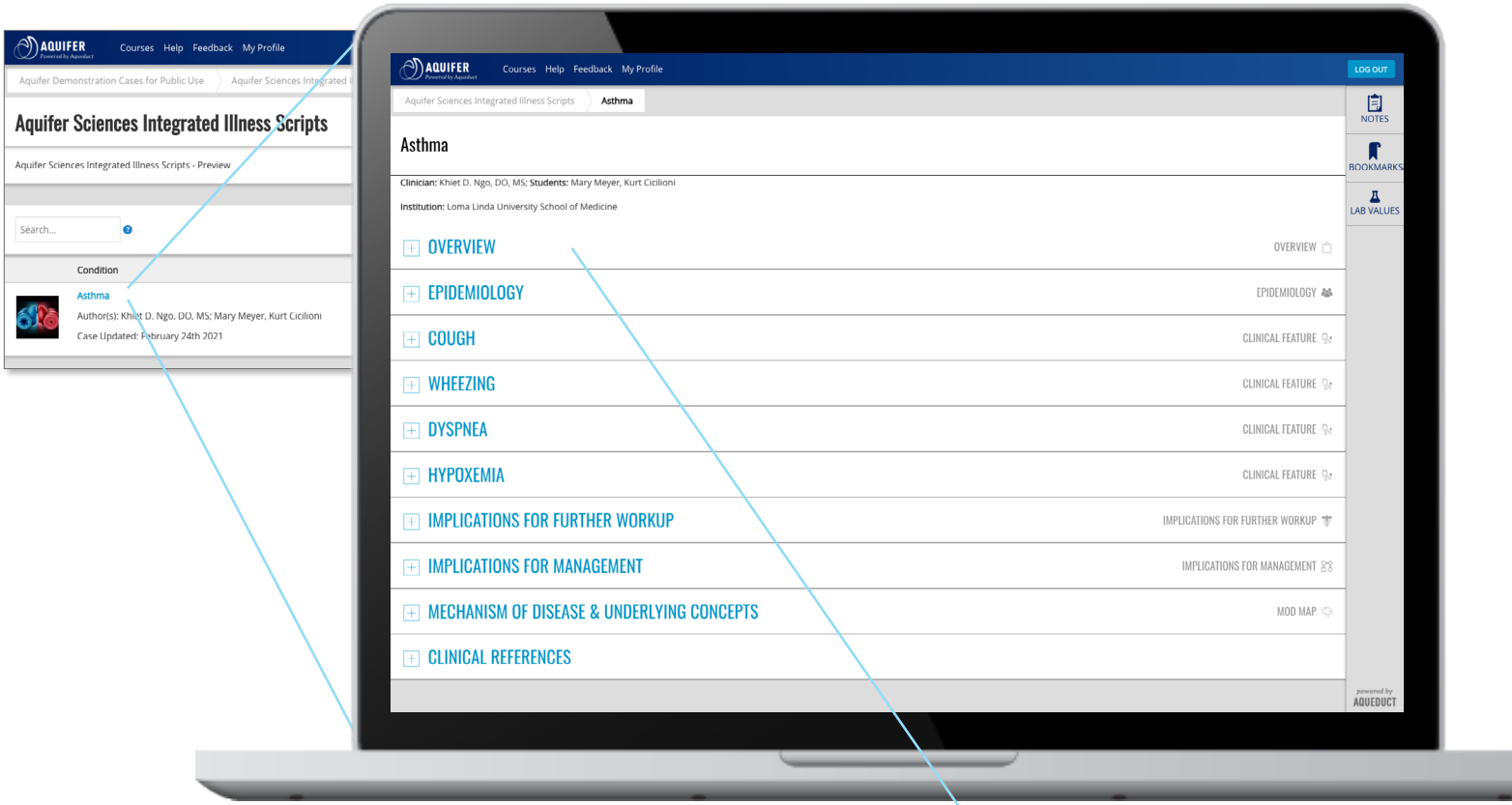
The curriculum includes:

- 11 Basic science disciplines
- 9 Clinical disciplines
- 105 Core concepts
- 789 Learning objectives
- 248 Common conditions
- 5 Clinical decisions
- 15 Systems

The Aquifer Sciences Curriculum is freely available via a searchable database that allows for detailed search and filtering options.

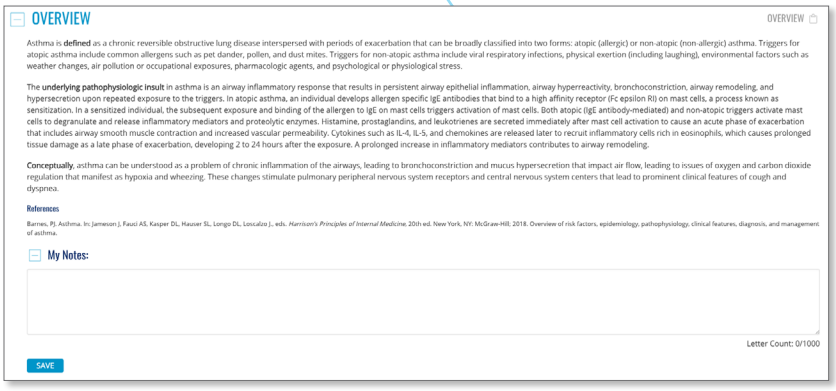
ANATOMY OF INTEGRATED ILLNESS SCRIPTS

Integrated Illness Scripts provide support for inductive reasoning, carrying the learner from observed clinical features back through relevant mechanisms and basic science concepts to the original insult. The journey follows the methods of reasoning a clinician would use to determine the cause of a disease or condition. The accompanying Mechanism of Disease Map is a visual representation of the path from the initial insult through the causal mechanisms to the observable clinical features.



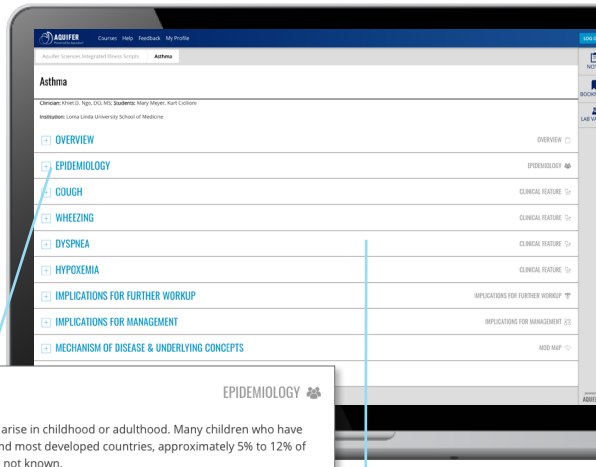
Overview

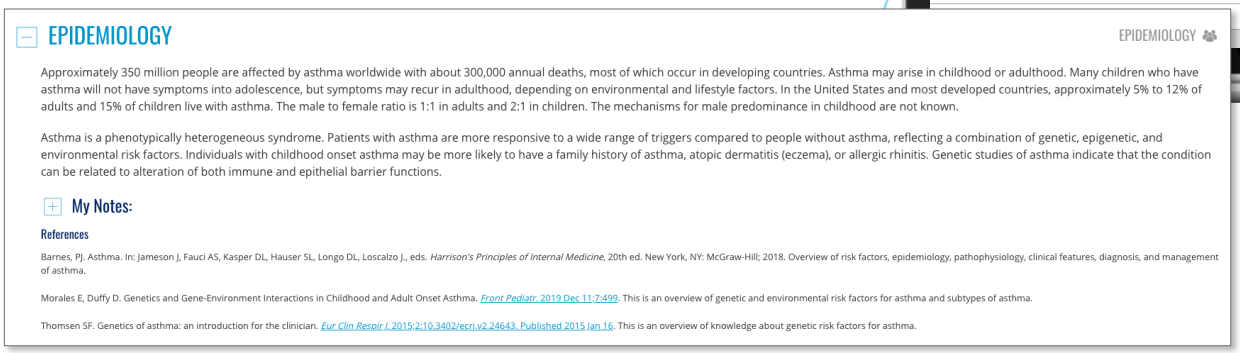
Each IIS begins with a brief clinical definition and description of the initial pathophysiological insult and the explanation for why the features of the disease arise.



Epidemiology

The Epidemiology (or enabling conditions) section describes risk factors and their underlying mechanisms, highlighting pathology and genetics concepts. This content ensures basic science mechanisms that explain why the enabling conditions leading to the disease are included to the greatest extent possible. Integrated Illness Scripts have a deep focus on the science behind the epidemiologic factors, striving to ensure that racial and other biases that have no evidentiary foundation are not carried forward.





EPIDEMIOLOGY

EPIDEMIOLOGY

Approximately 350 million people are affected by asthma worldwide with about 300,000 annual deaths, most of which occur in developing countries. Asthma may arise in childhood or adulthood. Many children who have asthma will not have symptoms into adolescence, but symptoms may recur in adulthood, depending on environmental and lifestyle factors. In the United States and most developed countries, approximately 5% to 12% of adults and 15% of children live with asthma. The male to female ratio is 1:1 in adults and 2:1 in children. The mechanisms for male predominance in childhood are not known.

Asthma is a phenotypically heterogeneous syndrome. Patients with asthma are more responsive to a wide range of triggers compared to people without asthma, reflecting a combination of genetic, epigenetic, and environmental risk factors. Individuals with childhood onset asthma may be more likely to have a family history of asthma, atopic dermatitis (eczema), or allergic rhinitis. Genetic studies of asthma indicate that the condition can be related to alteration of both immune and epithelial barrier functions.

My Notes:

References

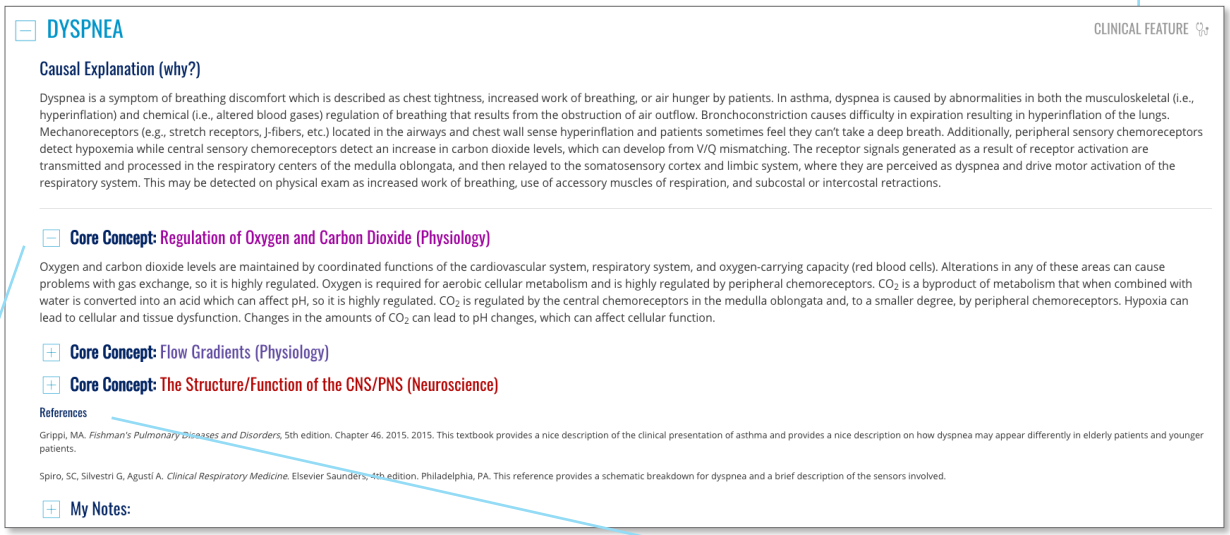
Barnes, PJ. Asthma. In: Jameson J, Fauci AS, Kasper DL, Hauser SL, Longo DL, Loscalzo J., eds. *Harrison's Principles of Internal Medicine*, 20th ed. New York, NY: McGraw-Hill; 2018. Overview of risk factors, epidemiology, pathophysiology, clinical features, diagnosis, and management of asthma.

Morales E, Duffy D. Genetics and Gene-Environment Interactions in Childhood and Adult Onset Asthma. *Front Pediatr*. 2019 Dec 11;7:499. This is an overview of genetic and environmental risk factors for asthma and subtypes of asthma.

Thomsen SF. Genetics of asthma: an introduction for the clinician. *Eur Clin Respir J*. 2015;2:10.3402/ecrj.v2.24643. Published 2015 Jan 16. This is an overview of knowledge about genetic risk factors for asthma.

Clinical Features

The Clinical Features articulate the most common presenting clinical findings (up to six per script), a description of how that finding would be 'discovered' by a clinician, and–most importantly–the basic science causal mechanisms that explain why each feature occurs in the condition. Each Clinical Feature provides the inductive reasoning from the observation of a feature by a clinician back through the relevant basic science mechanisms all the way to the underlying pathophysiologic insult. The relevant basic science core concepts are concisely listed to further support the connections to the underlying concepts of each Clinical Feature.



DYSPNEA

CLINICAL FEATURE

Causal Explanation (why?)

Dyspnea is a symptom of breathing discomfort which is described as chest tightness, increased work of breathing, or air hunger by patients. In asthma, dyspnea is caused by abnormalities in both the musculoskeletal (i.e., hyperinflation) and chemical (i.e., altered blood gases) regulation of breathing that results from the obstruction of air outflow. Bronchoconstriction causes difficulty in expiration resulting in hyperinflation of the lungs. Mechanoreceptors (e.g., stretch receptors, J-fibers, etc.) located in the airways and chest wall sense hyperinflation and patients sometimes feel they can't take a deep breath. Additionally, peripheral sensory chemoreceptors detect hypoxemia while central sensory chemoreceptors detect an increase in carbon dioxide levels, which can develop from V/Q mismatching. The receptor signals generated as a result of receptor activation are transmitted and processed in the respiratory centers of the medulla oblongata, and then relayed to the somatosensory cortex and limbic system, where they are perceived as dyspnea and drive motor activation of the respiratory system. This may be detected on physical exam as increased work of breathing, use of accessory muscles of respiration, and subcostal or intercostal retractions.

Core Concept: Regulation of Oxygen and Carbon Dioxide (Physiology)

Oxygen and carbon dioxide levels are maintained by coordinated functions of the cardiovascular system, respiratory system, and oxygen-carrying capacity (red blood cells). Alterations in any of these areas can cause problems with gas exchange, so it is highly regulated. Oxygen is required for aerobic cellular metabolism and is highly regulated by peripheral chemoreceptors. CO_2 is a byproduct of metabolism that when combined with water is converted into an acid which can affect pH, so it is highly regulated. CO_2 is regulated by the central chemoreceptors in the medulla oblongata and, to a smaller degree, by peripheral chemoreceptors. Hypoxia can lead to cellular and tissue dysfunction. Changes in the amounts of CO_2 can lead to pH changes, which can affect cellular function.

Core Concept: Flow Gradients (Physiology)

Core Concept: The Structure/Function of the CNS/PNS (Neuroscience)

References

Grippi, MA. *Fishman's Pulmonary Diseases and Disorders*, 5th edition. Chapter 46. 2015. 2015. This textbook provides a nice description of the clinical presentation of asthma and provides a nice description on how dyspnea may appear differently in elderly patients and younger patients.

Spiro, SC, Silvestri G, Agusti A. *Clinical Respiratory Medicine*. Elsevier Saunders; 4th edition. Philadelphia, PA. This reference provides a schematic breakdown for dyspnea and a brief description of the sensors involved.

My Notes:

Core Concepts

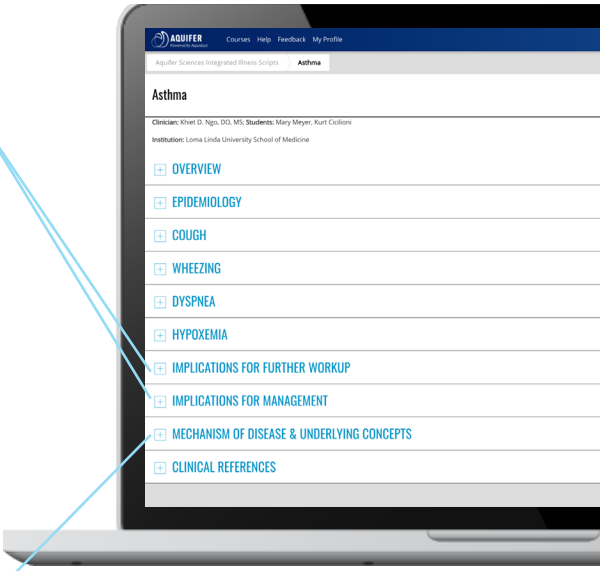
The underlying Core Concepts–the conceptual foundation on which both the IIS and the Mechanism of Disease Maps are built–are drawn directly from the nationally developed Aquifer Sciences Curriculum (see pg. 7). Core Concepts are explicitly included in the Clinical Features and Mechanism of Disease Map section of an IIS, connecting clinical observations and causations to foundational basic science knowledge.

References

References are included in each section, providing links to the supporting evidence, as well as suggested foundational reading for further study.

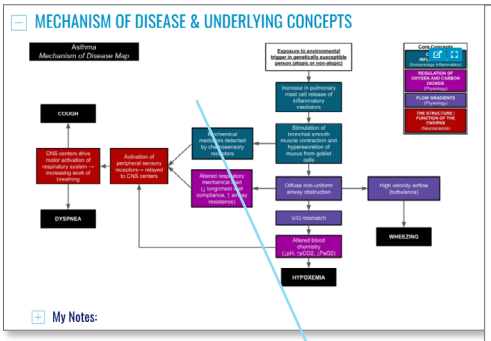
Implications for Further Workup & Management

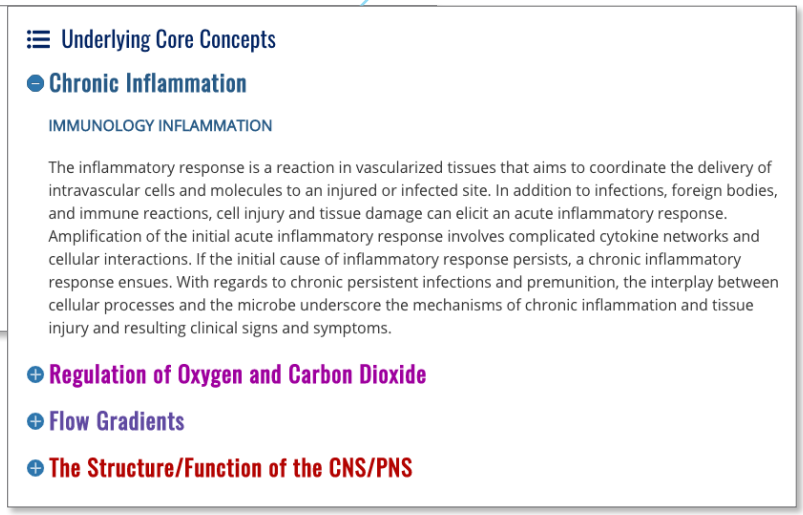
These sections are open notes fields to provide students an opportunity to reflect and record how this knowledge will influence their clinical practice in diagnosing and treating a patient with this condition.

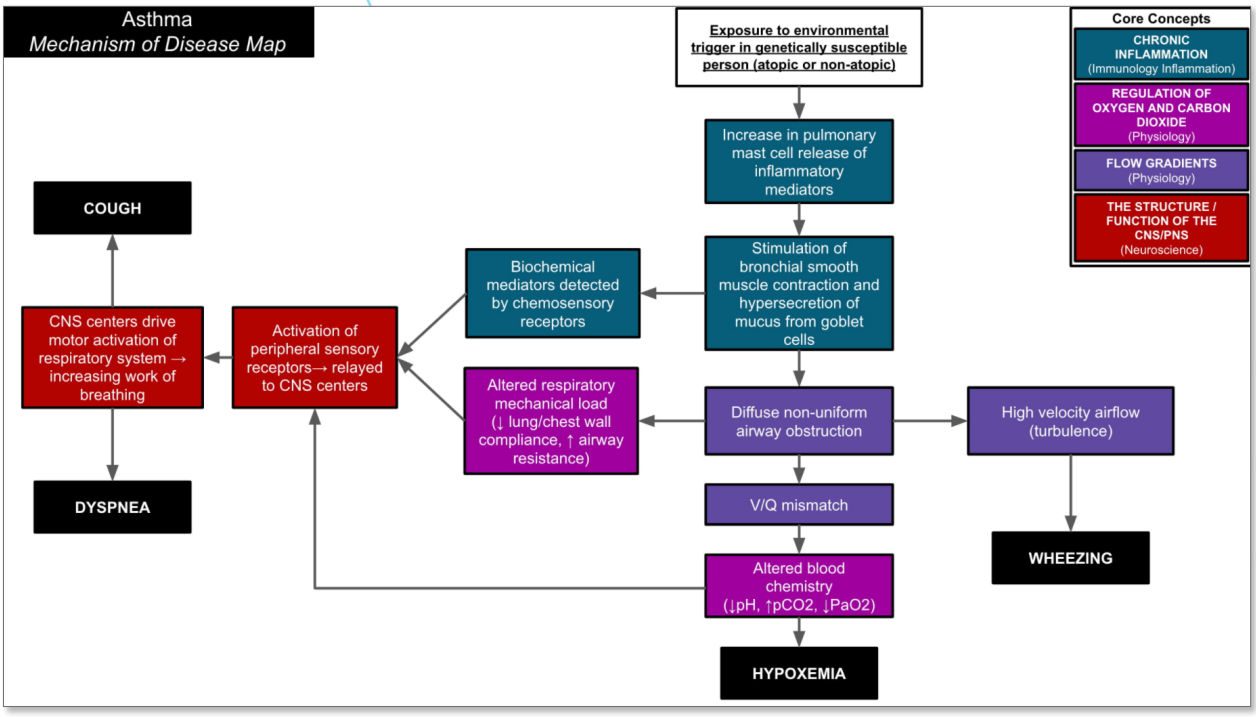


Mechanism of Disease Map

The Mechanism of Disease Map (MOD Map) is a unique type of concept map that flows in the manner that a basic scientist would explain the occurrence of a clinical feature in a known disease, providing an integrated scientific view of the condition. The MOD Map is a holistic and deductive visual representation of the clinical path from the original insult (or disease trigger), through the causal mechanisms of disease and their corresponding core basic science concepts to the resulting clinical features seen at presentation.







CONCLUSION

Integrated Illness Scripts provide medical and health professions learners with an invaluable framework from which to scaffold knowledge and bridge the gap between basic science and clinical learning. Developing a deep understanding of the "why" underlying each condition enhances the learners' ability to recall and retain information across the entire spectrum of the health professions curriculum. Integrated Illness Scripts are specifically designed to promote cognitive integration and interdisciplinary teaching, with the goal of advancing medical and health professions education by improving efficient and safe clinical decisions in novice clinicians.

ACCESSING INTEGRATED ILLNESS SCRIPTS

An initial set of the Aquifer Sciences Integrated Illness Scripts will be available free of charge to Aquifer Curricular Partners on July 1, 2021. Aquifer Curricular Partners are programs that subscribe to all five subscription-based Aquifer signature courses.

To view a demo script or learn more about using IIS in the classroom or clinic, please visit Aquifer.org.

REFERENCES

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2. Kulasegaram KM, Manzone JC, Ku C, Skye A, Wadey V, Woods NN. Cause and effect: Testing a mechanism and method for the cognitive integration of basic science. Academic Medicine. 2015;90(11):s63-9.

3. AAMC and Howard Hughes Medical Institute. Scientific Foundations for Future Physicians. 2009; https://www.aamc.org/system/files?file=2020-02/scientificfoundationsforfuturephysicians.pdf.

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5. Integrated Illness Scripts author schools: Albert Einstein College of Medicine, Case Western Reserve University School of Medicine, Loma Linda University School of Medicine, Philadelphia College of Osteopathic Medicine, University of Utah School of Medicine, and Western Michigan University Homer Stryker MD School of Medicine.